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A MODEL FOR DECAYS OF BOSON RESONANCES WITH ARBITRARY SPINS

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МОДЕЛЬ ДЛЯ РАСПАДОВ БОЗОННЫХ РЕЗОНАНСОВ С ПРОИЗВОЛЬНЫМ СПИНОМ

Получена формула для ширины распада резонанса со спином J на частицы a и b с произвольными спинами. Ширина выражена через s - канальные спиральные вычеты $G^{a\alpha_J b}_{\lambda_a \lambda_b}(t)$ реджео на α_J, на котором расположен резонанс J. Полученная формула применена к распадам резонансов, лежащих на траекториях векторно-тензорной группы, на псевдоскаляр и вектор, два вектора и $N\bar{N}$ - пару. Вычисления основаны на предсказаниях кварк-глюонной картины для связи кварков с реджеонами и $SU(6)$- - классификации адронов a и b.

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A MODEL FOR DECAYS OF BOSON RESONANCES WITH ARBITRARY SPINS

A formula for the width of resonance with spin J decay into ~~particles~~ hadrons ~~{a and b}~~ with arbitrary spins is derived. This width is expressed via S-channel helicity residues $\cancel{\{G^{a\alpha_J b}_{\lambda_a \lambda_b}(t)\}}$ of Regge trajectory α_J where the resonance J lies. Using the quark-gluon picture predictions for the coupling of quarks with Regge trajectories and SU(6)-classification of hadrons ~~{a and b}~~ this formula is applied to calculate the widths of decays of resonances, which lie on the vector and tensor trajectories, into pseudoscalar and vector, two vectors and $N\bar{N}$-pair.

Yerevan Physics Institute

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1. Introduction

In the absence of the exact theory of confinement one of the approaches to the investigation of the hadron interaction at large distances, where the effects of confinement are essential, is the so-called quark-gluon picture (QGP) based on the dual-topological expansion [1-6] and the string and color tube models [7-11].

The QGP approach allows one to consider from the unique point of view the production of hadrons both in the peripheral and in the hard processes. This approach has been applied successfully to different aspects of hadron physics such as the resonances masses calculation [12], the multiparticle processes description [13-18], etc.

The powers of this approach can be enlarged significantly by introduction of spin. In particular, it allows one to study the structure of the quark-quark scattering amplitude (qq-amplitude) which enters as constituent block into the hadron-hadron amplitudes.

The high-energy behavior of qq-amplitude was studied in [19]. The planar multiperipheral QGP, where the quarks emit and absorb the nonperturbative objects - "gluons", was considered. This picture was shown to explain the position of the secondary Regge trajectories (ρ, ω, A_2, f, π, A_1, K, K^*) in the j-plane. Moreover, for each group of poles with given σP and $G(-1)^{I}\sigma$ (σ, P, G, I – are the Regge pole signature, P - parity, G - parity and isospin) the definite spin structure of interaction with quark is predicted. In particular, the spin structure of the interaction of quarks with the rightmost trajectories of vector-tensor (V-T) group (ρ, ω, A_2, f) turns out to be of electromagnetic type and conserves at $S \gg \mu_N^2$ the S-channel helicity of quarks.

The absence of spin-flip interaction in qq-amplitudes contradicts at first sight the large variety of spin effects manifested by hadron amplitudes since in the traditional additive quark model (AQM) approach the hadron helicity flip is impossible without the quark one. The traditional AQM approach was revised critically in [20]: it was shown that the use of the nonrelativistic SU(6) wave functions in the final state contradicts the relativistic invariance and that the correct construction of the hadron wave functions at $S \gg \mu_N^2$ leads to the hadron spin flip even without the quark one *).

The analysis of works [20, 21] indicates the important role of the hadron wave functions in the formation of the spin effects. As examples, which demonstrate this role, one can note the calculations of the nucleon anomalous magnetic momenta [22] and of the helicity structure of the $N \to N$ and $N \to \Delta$ transitions [20], carried out in the infinite momentum frame. It is interesting to study more systematically the spin processes in the framework of this picture.

The aim of the present paper is to apply the QGP-approach to the decays

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*) We are grateful to A.Krzywicki who drew our attention to the work [21] wherein the analogous results were derived.

of resonances into spin particles. In Sec.2 we will obtain a general formula which expresses the width $\Gamma_{J\to ab}$ of spin J resonance decay into particles a and b via the S-channel helicity residues $G^{a\alpha_J b}_{\lambda_a \lambda_b}(t)$ of Regge trajectory α_J, where the resonance J lies. The practical use of this formula is connected with the calculation of the vertices $G^{a\alpha_J b}_{\lambda_a \lambda_b}(t)$

In our paper we consider the case of the V-T-group trajectories and use the SU(6)-classification of hadrons a and b. In Sec.3 we give the SU(6) predictions for the helicity couplings of S-wave a and b hadrons (pseudoscalars, vectors, nucleons) to the trajectories of V-T-group, the quark coupling to these trajectories being the QGP-predicted electromagnetic form.

After this all, the considered helicity residues $G^{\bar{a}\alpha_J \bar{b}}_{\lambda_a \lambda_b}$ (and respectively the widths $\Gamma_{J\to ab}$) are expressed in terms of single function $a(t)$. For the analytic continuation of $a(t)$ to the point $t=\mu_J^2$ we use the parametrization arising in the dual models.

In Sec.4 the predictions for the decays of resonances of V-T-group into pseudoscalar and vector, two vectors and $N\bar{N}$ -pair are given. The model predicts a definite mechanism of SU(3)-symmetry violation which increases with the growth of the spin J. The theoretical predictions are in good agreement with the experimental data.

2. The Partial Widths of Decays

In this Section we will obtain a formula for the width $\Gamma_{J\to ab}$ of decay of resonance with spin J into particles a and b with arbitrary spins.

Consider the scattering

$$a b \to a' b'$$

$$t = (P_a + P_b)^2 \qquad S = (P_a + P_{\bar{a}})^2 \tag{2.1}$$

The contribution of spin J resonance to the t-channel amplitude of process (2.1) has the form:

$$\mathcal{M}^{t\ res}_{\lambda_a \lambda_b \to \lambda'_a \lambda'_b}(S,t) = F^{J\ res}_{\lambda_a \lambda_b \to \lambda'_a \lambda'_b}(t) \times \tag{2.2}$$

$$\times\, d^{J}_{\lambda_b - \lambda_a,\, \lambda'_b - \lambda'_a}(z_t)$$

where

$$F^{J\ res}_{\lambda_a \lambda_b \to \lambda'_a \lambda'_b}(t) = \sum_{\lambda_J} \frac{\langle \lambda_a \lambda_b | S | \lambda_J \rangle \langle \lambda_J | S^+ | \lambda'_a \lambda'_b \rangle}{t - \mathcal{M}_J^2 + i \mathcal{M}_J \Gamma_0}$$

$$z_t = 1 + \frac{S}{2P_t^2} \tag{2.3}$$

The width of decay $J \to ab$ is expressed via $\langle \lambda_a \lambda_b | S | \lambda_J \rangle$ in the following way:

$$\Gamma_{J \to ab} = \frac{P_t}{8\pi \mathcal{M}_J^2} \frac{1}{2J+1} \sum_{\lambda_a \lambda_b \lambda_J} |\langle \lambda_a \lambda_b | S | \lambda_J \rangle|^2 \tag{2.4}$$

where $P_t = \frac{1}{2\mathcal{M}_J} \sqrt{[\mathcal{M}_J^2 - (m_a + m_b)^2][\mathcal{M}_J^2 - (m_a - m_b)^2]}$

is the decay momentum.

Since at large S

$$d^J_{\lambda\lambda}(z_t \gg 1) \approx \frac{(2J)!}{(J+\lambda)!(J-\lambda)!} \frac{S^J}{4^J P_t^{2J}}$$

then

$$\Gamma_{J\to a b} = \left(\frac{4P_t^2}{s}\right)^J \frac{P_t}{8\pi \mathcal{M}_J^2\ (2J+1)!} (t - \mathcal{M}_J^2 + i\mathcal{M}_J\Gamma_0)\times$$

$$\times \sum_{\lambda_a\lambda_b} (J + \lambda_a - \lambda_b)!\ (J - \lambda_a + \lambda_b)!\ \times \tag{2.5}$$

$$\times\ {}^{t}\mathcal{M}^{res}_{\lambda_a\lambda_b\to\lambda_a\lambda_b}(s \gg \mathcal{M}_N^2,\ t \approx \mathcal{M}_J^2)$$

Consider now the s -channel of process (2.1), i.e. the process $a\bar{a} \to \bar{b} b$ at large s . The contribution of Regge pole α_J to helicity amplitude ${}^{s}\mathcal{M}^{\alpha_J}_{\lambda_a\lambda_{\bar{a}}\to\lambda_{\bar{b}}\lambda_b}$ has the form:

$${}^{s}\mathcal{M}^{\alpha_J}_{\lambda_a\lambda_{\bar{a}}\to\lambda_{\bar{b}}\lambda_b}(s,t) = \frac{\pi s}{\bar{s}}\, g^{\bar{a}\alpha_J b}_{\lambda_a\lambda_b}(t)\, g^{a\alpha_J\bar{b}}_{\lambda_a\lambda_{\bar{b}}}(t)\times \tag{2.6}$$

$$\times\left(\frac{s}{s^{ab}_{ij}}\right)^{\alpha_J(t)-1}\eta[\alpha_J(t)]$$

Here $\bar{s}$ = 1 GeV^2, $\eta[\alpha_J(t)]$ is a signature factor and s^{ab}_{ij} is a scale factor which can depend on the type of particles a and b and on the quark content of trajectory α_J (see Sec.3).

The quantities $g^{a\alpha_J b}_{\lambda_a\lambda_b}(t)$ are connected to helicity residues $G^{a\alpha_J b}_{\lambda_a\lambda_b}(t)$ in the following way:

$$g^{a\alpha_J b}_{\lambda_a\lambda_b}(t) = (-t)^{\frac{|\lambda_a-\lambda_b|}{2}}\, G^{a\alpha_J b}_{\lambda_a\lambda_b}(t) \tag{2.7}$$

Expressing ${}^{t}\mathcal{M}$ with the help of the crossing matrix [23] via ${}^{s}\mathcal{M}$ at $t \equiv t_J \approx \mathcal{M}_J^2$ we get finally

$$\Gamma_{J\to a b} = \left(\frac{4P_t^2}{s^{ab}_{ij}}\right)^{J-1}\frac{P_t^3}{\pi\mathcal{M}_J^2\ (2J+1)!}\times \tag{2.8}$$

$$\times \sum_{\lambda_a \lambda_b \{\mu_i\}} (-1)^{\Sigma \mu_i} (J+\lambda_a-\lambda_b)!\,(J-\lambda_a+\lambda_b)!\, d^{S_a}_{\mu_1 \lambda_a}(\psi_a)\, d^{S_b}_{\mu_2 \lambda_b}(\pi-\psi_b) \times$$

$$\times d^{S_a}_{\mu_3 \lambda_a}(\pi-\psi_a)\, d^{S_b}_{\mu_4 \lambda_b}(\psi_b)\, g^{a\alpha_J \bar{b}}_{\mu_1 \mu_2}(t_J)\, g^{\bar{a}\alpha_J b}_{\mu_3 \mu_4}(t_J)\,.$$

At large S the angles ψ_a and ψ_b have the form

$$\cos\psi_a = \frac{\mathcal{M}_J^2+m_a^2-m_b^2}{2\mathcal{M}_J P_t} = \frac{E_t^a}{P_t}\,; \qquad \sin\psi_a = i\,\frac{m_a}{P_t}$$

$$\cos\psi_b = \frac{\mathcal{M}_J^2-m_a^2+m_b^2}{2\mathcal{M}_J P_t} = \frac{E_t^b}{P_t}\,; \qquad \sin\psi_b = i\,\frac{m_b}{P_t}$$

Formula (2.8) determines the relation between $\Gamma_{J\to ab}$ and S - channel residues of the corresponding trajectory α_J .

The practical application of this formula consists in the calculation of residues $G^{a\alpha_J b}_{\lambda_a \lambda_b}(t)$. In the present paper formula (2.8) will be applied to the decays of resonances lying on V-T-trajectories. To calculate the relations between the residues we will use the SU(6)-quark model.

We will consider the decays into particles which are S -wave states of quarks, i.e. the decays into two pseudoscalars ($J\to PP$ decays), pseudoscalar and vector ($J\to PV$), two vectors ($J\to VV$) and $N\bar{N}$ -pair ($J\to N\bar{N}$). For these decays formula (2.8) reduces to

a) $J\to PV$ decay

$$\Gamma_{J\to PV} = \left(\frac{4P_t^2}{S_{ij}^{ab}}\right)^J \frac{S_{ij}^{a\beta} P_t}{2\pi}\, \frac{(J+1)!\,(J-1)!}{(2J+1)!} \left(G_{0\ 1}^{P\alpha_J V}(t)\right)^2 \qquad (2.9)$$

b) $J\to VV$ decay (the spin-flip residues $G_{0\ 1}^{V\alpha V}(t)$ are zero in AQM-approach (see Sec.3a))

$$\Gamma_{J\to VV}=\left(\frac{4P_t^2}{S_{ij}^{ab}}\right)^J \frac{S_{ij}^{ab}}{4\pi \mathcal{M}_J^2 P_t^3}\ \frac{1}{(2J+1)!}\left(G_{1\ \ 1}^{V\alpha_J V}(t_J)\right)^2\times$$

$$\times\Big\{(J!)^2\left(P_t^4+6m_V^4+4m_V^2P_t^2\right)+2(J+1)!(J-1)!\,\mathcal{M}_J^2 m_V^2+ \tag{2.10}$$

$$+\frac{1}{8}(J+2)!\,(J-2)!\,\mathcal{M}_J^4\Big\}\ .$$

c) $J\to N\tilde{N}$ **decay**

$$\Gamma_{J\to N\tilde{N}}=\left(\frac{4P_t^2}{S_{ij}^{ab}}\right)^J\frac{S_{ij}^{ab}}{2\pi\mathcal{M}_J^2P_t}\ \frac{1}{(2J+1)!}\Big\{\left(G_{1/2\ \ 1/2}^{N\alpha_J N}(t_J)\right)^2\times$$

$$\times\left[(J!)^2m_N^2+\frac{1}{4}\mathcal{M}_J^2(J+1)!(J-1)!\right]-2\,G_{1/2\ \ 1/2}^{N\alpha_J N}(t_J)\times \tag{2.11}$$

$$\times G_{1/2\ -1/2}^{N\alpha_J N}(t_J)\left[(J!)^2+(J+1)!\,(J-1)!\right]\mathcal{M}_J^2m_N+2\left(G_{1/2\ -1/2}^{N\alpha_J N}(t_J)\right)^2\times$$

$$\times\left[(J!)^2\frac{\mathcal{M}_J^2}{4}+(J+1)!\,(J-1)!\,m_N^2\right]\mathcal{M}_J^2\Big\}$$

d) $J\to PP$ **decay**

$$\Gamma_{J\to PP}=\left(\frac{4P_t^2}{S_{ij}^{ab}}\right)^J\frac{S_{ij}^{ab}\,P_t}{4\pi\mathcal{M}_J^2}\ \frac{(J!)^2}{(2J+1)!}\left(G_{0\ \ 0}^{P\alpha_J P}(t_J)\right)^2 \tag{2.12}$$

Formula (2.12) was obtained previously in [24].

3. Parameters of Model

a) The Relations Between the Helicity Residues.

For the calculation of the relations between the residues we will use the AQM-approach to the classification of hadrons a and b.

As it was shown in the framework of planar multiperipheral QGP [19], the spin structure of qq-amplitude, which corresponds to the exchange in t-channel of the poles of V-T group, has the electromagnetic form

$$V_q = a\, \bar{q}_3 \gamma^{\mu} q_1 \bar{q}_2 \gamma_{\mu} q_4 \tag{3.1}$$

which conserves at $S = (P_1 + P_2)^2 \gg m_N^2$ the S-channel helicity of quarks

$$V_q^{S\to\infty} \propto S\, \delta_{\lambda_3\lambda_1} \delta_{\lambda_2\lambda_4} \tag{3.2}$$

The wave functions of initial hadrons have the SU(6)-nonrelativistic structure

$$\Psi_{in}^{h} = \Psi_{SU(6)}^{h} \tag{3.3}$$

In the process of interaction the final hadron acquires the transverse momentum $\vec{q}_{\perp}$. As a result, the SU(6)-structure of the final hadron is violated [20]

$$\Psi_{f}^{h} = V(\vec{q}_{\perp})\, \Psi_{SU(6)}^{h} \tag{3.4}$$

For mesons the $V(\vec{q}_{\perp})$ matrix has the form

$$V_{h\to q\bar{q}}(\vec{q}_{\perp}) = 1 + \frac{i\, \varepsilon_{em}\, q_e}{4 m_q} (\sigma_b - \sigma_a)_m \tag{3.5}$$

For the three-quark states

$$V_{h \to 3q}(\vec{q}_\perp) = 1 + \frac{i\mathcal{E}em\,q_e}{6m_q}(\sigma_b + \sigma_c - \sigma_a)m \tag{3.6}$$

In expressions (3.5) and (3.6) the active quark is the quark „a" .

From (3.5) and (3.6) one can see that in the hadron-quarks vertices the helicity can be nonconserved. This leads to the hadron-hadron helicity-flip transitions even in the case of nonflip interaction (3.1) at the quark level.

Using the wave functions (3.3)-(3.6) and qq-interaction (3.1) we get the predictions for the various helicity residues of Regge poles of V-T-group. Thus for the spin nonflip diagonal transitions AOM predicts the following relations:

$$G^{a\alpha a}_{\lambda a\,\lambda a} = \frac{a}{\sqrt{2}}\left(N^a_u + \sigma_\alpha N^a_{\bar{u}} + (-1)^{I_\alpha} N^a_d + \sigma_\alpha (-1)^{I_\alpha} N^a_{\bar{d}}\right), \tag{3.7}$$

$$\alpha = \rho, \omega, A_2, f\text{ - trajectories},$$

$$G^{a\beta a}_{\lambda a\,\lambda a} = a\left(N^a_s + \sigma_\beta N^a_{\bar{s}}\right) \tag{3.8}$$

$$\beta = \varphi, f'\text{ - trajectories}$$

where N^a_i is the number of quarks of type „i" in the hadron a , σ_α and I_α are the signature and isospin of pole α .

The relations (3.7) and (3.8) were obtained for the first time in the paper [25] on the basis of the accounting of the planar diagrams. The authors of [25] noted that their relations correspond to the electromagnetic interaction of quarks.

The analogous transitions with the change of the strangeness have the form:

$$G^{a\gamma\beta}_{\lambda a \lambda a} = a\left(\sqrt{N^a_d N^b_s} + \sqrt{N^a_{\bar{s}} N^b_{\bar{d}}}\right) \qquad (3.9)$$

$$\gamma = K^*, \; K^{**}\text{-trajectories}$$

The relations between residues of the spin-flip P-V-transitions look as

$$G^{P\alpha V}_{0\;1} = \frac{a}{4m_q}\left(\sqrt{N^P_u N^V_u} - \sigma_\alpha \sqrt{N^P_{\bar{u}} N^V_{\bar{u}}} + (-1)^{I_\alpha - I_P - I_V} \times\right.$$

$$\left.\times \sqrt{N^P_d N^V_d} - \sigma_\alpha (-1)^{I_\alpha - I_P - I_V} \sqrt{N^P_{\bar{d}} N^V_{\bar{d}}}\right)$$

$$G^{P\beta V}_{0\;1} = \frac{a}{2\sqrt{2}\, m_q}\left(\sqrt{N^P_s N^V_s} - \sigma_\beta \sqrt{N^P_{\bar{s}} N^V_{\bar{s}}}\right) \qquad (3.10)$$

$$G^{P\gamma V}_{0\;1} = \frac{a}{2\sqrt{2}\, m_q}\left(\sqrt{N^P_d N^V_s} + \sqrt{N^P_{\bar{s}} N^V_{\bar{d}}}\right)$$

The spin-flip coupling of reggeons with baryons $\left(1/2\right)^+$ is

$$G^{B\alpha B}_{1/2\;-1/2} = \frac{\sqrt{2}\, a}{12 m_q}\left[\left(6\,(Y_B I^3_B)^2 - 1\right)\left(N^B_u + (-1)^{I_\alpha} N^B_d\right) -\right.$$

$$\left. - 3 Y_B I^3_B \left(N^B_u - (-1)^{I_\alpha} N^B_d\right)\right] \qquad (3.11)$$

$$G^{B\beta B}_{1/2\;-1/2} = \frac{2a}{3m_q}\left[-1 + \frac{1}{2}\,|Y_B|\,(N^B_s + 2)\right]$$

where Y_B and I_B^3 are the hypercharge and the projection of isospin.

As to the spin-flip V-V-transitions, they are zero in the quark model.

b) Analytic Continuation in t.

The next step is the choice of the analytic continuation of functions $g^{a\alpha\beta}_{\lambda_a \lambda_b}(t)$ in t. It is worth reminding that

$$g^{a\alpha\beta}_{\lambda_a \lambda_b}(t) = (-t)^{\frac{|\lambda_a - \lambda_b|}{2}} G^{a\alpha\beta}_{\lambda_a \lambda_b}(t)$$

Since in our scheme all the functions $G^{a\alpha\beta}_{\lambda_a \lambda_b}(t)$ are expressed in terms of one quark residue $a(t)$, it is natural to suppose that the analytic continuation of $G^{a\alpha\beta}_{\lambda_a \lambda_b}(t)$ is determined by the analytic continuation of $a(t)$. For the continuation of $a(t)$ we assume that

$$a^2(t) = \frac{a_0^2}{\Gamma[\alpha(t)]} \tag{3.12}$$

where a_0 is a constant.

In [24] it was shown that this form, arising in dual models, allows one to describe with a good accuracy the widths (2.12) of decays of resonances of V-T group into two pseudoscalars.

c) The Parameters $S^{a\beta}_{ij}$.

Consider now the scale factors $S^{a\beta}_{ij}$. In [25] on the basis of interpretation of planar diagrams from the probability point of view it was shown that the quantities $S^{a\beta}_{ij}$ satisfy the following relations:

$$S^{a\beta}_{ij} = \sqrt{S^{aa}_{ii} \cdot S^{bb}_{jj}} \; ; \qquad \frac{S^{ab}_{ij}}{S^{ac}_{ij}} = \frac{\overline{X^c_j}}{\overline{X^b_j}} \tag{3.13}$$

where $\overline{\lambda}_i^a$ is the mean value of the momentum fraction carried by the valence quark of type „i" in the hadron a (see Fig.1)

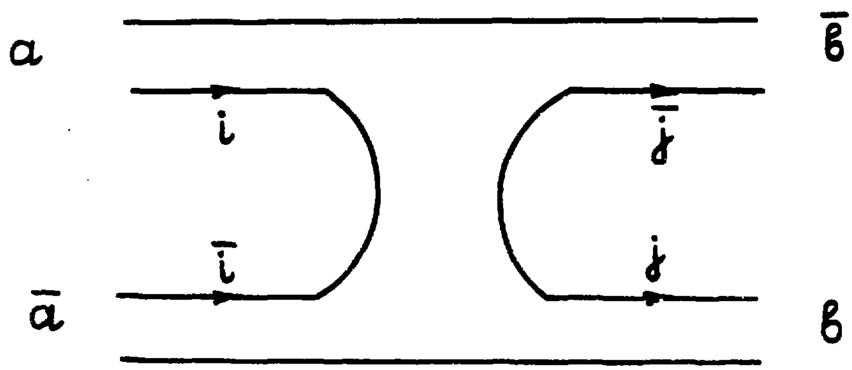

Fig. 1.

Formula (3.1?) determines the connection between the scale factors $S_{qs}^{\pi K}$, $S_{qq}^{\pi\pi}$ and S_{ss}^{KK} (q (s) is an ordinary (strangeness) quark). For the quantity S_{qq}^{KK} it was assumed [25] that

$$S_{qq}^{KK} = S_{ss}^{KK} \tag{3.14}$$

In [26] it was shown from the consideration of probability mechanism in the rapidity space that the quantity S_{ii}^{ab} can be written in the form:

$$S_{ii}^{ab} = \frac{m_i^{\perp}}{x_i^a} \; \frac{m_i^{\perp}}{x_i^b} \tag{3.15}$$

where $m_i^{\perp}$ is the transverse mass of quark i .

Note that the relations (3.13) and (3.15) agree with each other under assumption of the equality of the valence quarks rapidities, from which one gets

$$\bar{x}_i^a = \frac{m_i^\perp}{(\Sigma m_k^\perp)a} \tag{3.16}$$

The calculation of S_{ij}^{ab} in the framework of the considered in [19] multiperipheral mechanism is beyond the leading $\ln S$ approximation. It is interesting however to consider the γ^μ -interaction (3.1) which determines the asymptotic behavior of the planar qq-amplitude. At large S we have

$$V_q \propto \frac{S}{S_{ij}^{ab}} \tag{3.17}$$

where $S_{ij}^{ab} = C \frac{m_i m_j}{\bar{x}_i^a \bar{x}_j^b}$ (C is a constant).

The choice of S_{ij}^{ab} in the form (3.17) satisfies the relations (3.13). As to the (3.15) which contains $m_i^\perp$ (but not m_i), one can satisfy simultaneously the relations (3.13)-(3.17) taking into account the well known growth of $\langle \vec{q}_\perp^{\,2} \rangle$ with the growth of the quark mass *).

In our calculations we shall use the following values of S_{ij}^{ab} [24]:

$$S_{q\,q}^{a_q b_q} = 1{,}1 \ GeV^2 \tag{3.18}$$

where a_q and b_q are the nonstrange mesons.

$$S_{q\,q}^{a_s b_s} = S_{ss}^{a_s b_s} = S_{q\,q}^{a_q b_q} \cdot \left(\frac{\bar{x}_u^\pi}{\bar{x}_u^K}\right)^2 \tag{3.19}$$

a_s and b_s are the strange mesons.

$$S_{q\,s}^{a_q b_s} = \sqrt{S_{q\,q}^{a_q b_q} \cdot S_{s\,s}^{a_s b_s}} \tag{3.20}$$

*) Note that although the result of [24, 25-26] where the relations (3.13)-(3.16) are used agree well with experiment, a more realistic model is needed for verification of these relations.

$$S^{NN}_{qq} = S^{a_q b_q}_{q\ q} \cdot \left(\frac{\bar{X}^{\pi}_{u}}{\bar{X}^{N}_{u}}\right)^2 \qquad (3.21)$$

where

$$\frac{\bar{X}^{\pi}_{u}}{\bar{X}^{K}_{u}} = 1,1 \pm 0,05\ ; \qquad \frac{\bar{X}^{\pi}_{u}}{\bar{X}^{N}_{u}} = 1,6 \pm 0,1 \qquad (3.22)$$

4. Predictions of Model

Let us compare the predictions of our model with experimental data. In the model there are two free parameters - a_o and m_q which we fix from the experimental widths of the decays $\rho \to \pi\pi$ ($\Gamma_{\rho\to\pi\pi}$ =154±5 MeV) and $A_2 \to \rho\pi$ ($\Gamma_{A_2\to\rho\pi}$ = 78±5 MeV) [27].

The theoretical predictions are summarized in Tables 1-3. In the parentheses the predictions of unbroken SU(3) symmetry (i.e. at $S^{a_q b_s}_{q\ s} = S^{a_s b_s}_{q\ q} = S^{a_s b_s}_{s\ s}$) are given. In the second column the experimental data are presented. In the last column we give the value of momentum which was used for calculation of the given width: since $\Gamma_{J\to ab} \sim (P_t)^{2J}$, a small deviation in the definition of P_t can change significantly the value of $\Gamma_{J\to ab}$ at large J.

The theoretical predictions for the widths of $J \to PP$ decays were compared with the experiment in [24]. The comparison shows that the parametrization of residues in the form (3.12) and the violation of SU(3), which grows as $\left(S^{a_i b_s}_{i\ s} / S^{a_q b_q}_{q\ q}\right)^{J-1}$ $(i = q, s)$ with increasing J, describes well all existing data.

Two resonances of V-T-group K^* (2060) and ϕ (1860) have been observed recently [27]. In Table 1 the predictions for the decays of these resonances (and also for the ω (1670) $\to K\bar{K}$) into PP are given

A nice agreement between the theory and the experiment is seen for the width of $K^*(2060) \to K\pi$ decay.

As to the decays into particles with spin, the experimental information is rather scarce. During the last years in the Particles data Tables only the widths of decays $K^*(1430)$ into pseudoscalar and vector and $A_2 \to \rho\pi$ have been published. Data on the widths of the decays $g(1690) \to \omega\pi$ and $g \to \rho\rho$ are taken from [28].

Tables 2 and 3 demostrate the agreement of the model predictions on the decays $\mathcal{J} \to PV$ and $\mathcal{J} \to VV$ with experimental data, though, in contrast to $\mathcal{J} \to PP$ decays, the accuracy of these data does not allow one to examine the theoretical details. The new and more precise experiments which will involve the decays into the spin particles are needed.

Among the experiments which can be crucial for our model, the measurement of the $\omega(1670) \to \rho\pi$ decay is very intriguing. As is seen from Table 2, this decay is expected to dominate over other modes

$$Br(\omega(1670) \to \rho\pi) = (90 \pm 10)\%$$

5. Conclusion

The analysis of the spin phenomena in the framework of QGP is of special interest to check the adequacy of this approach and to understand the mechanisms which are responsible for the spin effects in the parton models.

In Ref.[19] QGP with spin was applied to the investigation of the structure of planar qq-amplitudes. In [20] the important role of the wave functions in the formation of the spin amplitudes of hadron scattering was demonstrated.

In the present paper the region of the applicability of QGP is enlarged to describe the decays which involve spin particles. The closed expression for the decay width of boson resonance with arbitrary spin J into particles a and b with arbitrary spins is obtained.

The model is applied to calculate the decay widths of resonances, which lie on the Regge-trajectories of V-T-group (ρ , ω , A_2 , f , K^* - trajectories), into pseudoscalars, vectors and baryons. For the calculations the QGP-predicted universal electromagnetic interaction of these trajectories with quarks and AQM are used. After that all the decays $J \to PP$, $J \to PV$, $J \to VV$, $J \to B\bar{B}$ are expressed only via two free parameters.

Let us turn to the comparison of the model predictions with the experiment. There are enough data on the decays into two pseudoscalars. The fact that the theoretical predictions are in good agreement with experiments (see [24] and Table 1) testifies the correctness of the model, especially the form of analytic continuation (3.12) and the mechanism of SU(3)-symmetry violation for these decays.

As to the decays into the spin particles, the experimental information is very poor. It is highly important to measure the decays of resonances with spins $J \geqslant 3$ into PV, VV and BB -pairs.

We considered the particular case of decays of V-T-group resonances into S -wave states P, V and B. The calculations of the decays of resonances which correspond to the trajectories of the scalar, pseudoscalar and axial groups are of interest. The model predicts the definite structure of the interaction of quarks with these trajectories. Furthermore, the decays into the particles which are not S -wave states of quarks, as well as into photons, can be considered.

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Table 1. The decays into two pseudoscalars

resonance	J^P	channel	Γ (MeV), theor.	Γ (MeV), exp.	P_t (MeV/c)
ω (1670)	3^-	$K\bar{K}$	4.2±0.2 (6.1)		670
ϕ (1850)	3^-	$K\bar{K}$	34±3 (48)		784
K^* (2060)	4^+	$K\pi$	17±3 (24)	15±5	966

Table 2. The decays into pseudoscalar and vector

resonance	J^P	channel	Γ (MeV), theor.	Γ (MeV), exp.	P_t (MeV/c)
f' (1525)	2^+	$K^*\bar{K}+\bar{K}^*K$	14±1 (17)		294
K^* (1430)	2^+	ρK	7.7±0.5 (8.5)	8.9±2.0	324
		ωK	2.1±0.1 (2.3)	4.3±2.0	310
		$K^*\pi$	27±2 (30)	24.8±4.0	417
g (1690)	3^-	$\omega\pi$	58±4	5 2±24	656
		$K^*\bar{K}+\bar{K}^*K$	4.0±0.3 (5.8)		471
ω (1670)	3^-	$\rho\pi$	152±12		648
		$K^*\bar{K}+\bar{K}^*K$	2.8±0.1 (4)		448
ϕ (1850)	3^-	$K^*\bar{K}+\bar{K}^*K$	52±4 (75)		601
K^* (1780)	3^-	ρK	25.3±1.6 (30)		620
		ωK	7.8±0.6 (9.4)		607
		$K^*\pi$	44±3 (53		657
		ϕK	[illegible]		[illegible]

Table 2. (cont's)

$K^*(2060)$	4^+	ρK ωK $K^*\pi$ ϕK	17±4 (23) 6±1 (7.8) 28±5 (36) 1.6±0.3 (2.2)		806 800 837 675

Table 3. The decays into two vectors and $N\bar{N}$-pair

resonance	J^P	channel	Γ (MeV), theor.	Γ (MeV), exp	P_t (MeV/c)
g (1690)	3^-	$\rho\rho$	82±3	45±31	352
ϕ (1850)	3^-	$K^* K^*$	30±2.5 (44)		252
h (2030)	4^+	$\rho\rho$ $\omega\omega$ $K^* K^*$ $N\bar{N}$	100±17 61±10 5.1±1.1 (8.0) $(52±8)\times10^{-3}$		661 645 482 384

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МОДЕЛЬ ДЛЯ РАСПАДОВ БОЗОННЫХ РЕЗОНАНСОВ С ПРОИЗВОЛЬНЫМ СПИНОМ

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