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PLANAR QUARK DIAGRAMS AND BINARY SPIN PROCESSES

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ՊԼԱՆԱՐ ՔՎԱՐԿԱՅԻՆ ԴԻԱԳՐԱՄՆԵՐ ԵՎ ԿՐԿՆԱԿԻ ՍՊԻՆԱՅԻՆ ՊՐՈՑԵՍՆԵՐ

Վերլուծվում է պլանար դիագրամների ներդրումը կրկնակի ցրման պրոցեսներում: Վերլուծությունը հիմնված է ուժեղ փոխազդեցությունների քվարկ-գլյուոնային պատկերի վրա՝ նպատակ ունենալով SU(6) դասակարգումը, ռեջեոնների և քվարկների կապը: Քննարկվում է ոչ պլանար ներդրումների կախվածությունը փոխազդող մասնիկների քվարկային կազմությունից և սպիններից:

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PLANAR QUARK DIAGRAMS AND BINARY SPIN PROCESSES

Contributions of planar diagrams to the binary scattering processes are analyzed. The analysis is based on the predictions of quark-gluon picture of strong interactions for the coupling of reggeons with quarks as well as on the SU(6)-classification of hadrons. The dependence of contributions of nonplanar corrections on spins and quark composition of interacting particles is discussed.

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ПЛАНАРНЫЕ КВАРКОВЫЕ ДИАГРАММЫ И БИНАРНЫЕ СПИНОВЫЕ ПРОЦЕССЫ

Анализируются вклады планарных диаграмм в процессы бинарного рассеяния. Анализ основан на предсказаниях кварк-глюонной картины сильных взаимодействий для связи реджеонов с кварками и SU(6) -классификации адронов. Обсуждается зависимость вкладов непланарных поправок от спинов и кваркового состава взаимодействующих частиц.

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1. Introduction.

The dual-topological expansion (DTE) of amplitudes of hadronic processes in the framework of SU(N_f) and SU(N_c) (N_f, N_c - is the number of flavors and colors) allows one to classify various Feynman diagrams on powers of quantity $1/N \sim 1/N_f \sim 1/N_c$ [1] .

Thus, secondary Regge trajectories ρ, A_2, ω, f ... correspond in DTE to the planar quark diagrams which make a main contribution to 1/N-expansion of binary amplitudes. As to the vacuum pole and the so-called cuts, they correspond to nonplanar diagrams of the 1/N-expansion.

At first sight, the DTE diagrams seem to be but formal topological objects: a practical use however shows that they allow quark-parton interpretation. This enables one to develop nonperturbative quantitative methods in order to describe strong interactions at large distances (see, e.g. Refs. [2]).

So long as the expansion of hadron scattering amplitudes on powers of 1/N is a series whose coefficients are dynamical functions of kinematical variables, then relative values of contributions with different topologies depend, in principle, on variation regions of these variables. In Ref. [3] a so-called "hypothesis of asymptotic planarity" was formulated, according to which a contribution of planar diagrams dominates in amplitudes of binary processes at large positive S and t . With decreasing t (with approaching the physical scattering region) the contribution of nonplanar diagrams increases.

A question arises as to carry out a more concrete quantitative analysis of a contribution of diagrams with different topologies to amplitudes of binary processes. Such analysis for total cross sections was carried out in Ref. [4] within the probability model based on colored tube representations. In this model, total cross sections are determined by contributions of topological objects of two types - planar part and cylindrical part corresponding in DTE to vacuum pole. As a result of that, certain relations between total cross sections of πN-, KN-, NN-and $N\bar{N}$ -scattering processes are predicted, which agree well with experimental data.

The purpose of this work is to analyze contributions of planar diagrams to the binary spin processes at high energies. Our model is based on results of Ref. [5] where the amplitude of quark-quark (qq^-) interaction was studied in the framework of the planar multiperipheral quark-gluon mechanism. This mechanism allows one to explain a position in j -plane of secondary Regge trajectories with different quantum numbers as well as to predict a definite spin structure in vertices of interaction of these trajectories with quarks.

When passing to hadron amplitudes, we shall use the additive quark model (AQM) with SU(6)-classification of hadrons.

As a result, a large number of relations between amplitudes of hadron processes with various spin structures is predicted. In Sect. 2 we give predictions of our approach for the relations between vertices of coupling of vector-tensor (V-T) group reggeons ($\rho, A_2, \omega, f, K^*, K^{**}\ldots$) with baryons and bosons. A comparison of these predictions with experimental data is carried out in Sect. 3. Contrary to the processes determined by contributions of V-T-group reggeons, the processes proceeding owing to other trajectories exchange (π^-, B^- etc.) are studied less in detail experimentally. A comparison of theoretical predictions with experimental data for these processes is carried out in Sect.4. In Sect.5, a contribution of nonplanar singularities (cuts etc.) to binary spin processes is discussed.

2. Relations Between Helicity Residues.

According to DTF, a contribution of planar diagrams to the amplitude $M_{ab\to cd}(S,t)$ of the process $ab \to cd$ corresponds to a contribution of secondary Regge poles $\alpha_i(t)$. In the S-channel helicity amplitude representation, the latter has the following form:

$$M^{pl}_{\lambda_a\lambda_b\to\lambda_c\lambda_d}(S,t)=\frac{\pi S}{\bar S}\sum_{\alpha_i}(-t')^{\frac{1}{2}(|\lambda_a-\lambda_c|+|\lambda_b-\lambda_d|)}\times$$

$$\times\, G^{a\alpha_i c}_{\lambda_a\lambda_c}(t)\, G^{b\alpha_i d}_{\lambda_b\lambda_d}(t)\,\eta[\alpha_i(t)]\left(\frac{S}{S^{ab}_{cd}}\right)^{\alpha_i(t)-1} \qquad (2.1)$$

where $t'=t-t_{min}$, $G^{a\alpha_i c}_{\lambda_a\lambda_c}(t)$ are helicity residues, $\eta[\alpha_i(t)]$ is a signature factor, $\bar S = 1\ \mathrm{GeV}^2$. S^{ab}_{cd} is a scale factor dependent, in principle, on a type of interacting particles (see [4]). To calculate relations between helicity residues $G^{a\alpha_i b}_{\lambda_a\lambda_b}$, we use results of Ref. [5] and AQM with SU(6)-classification of hadrons. The qq-amplitude, corresponding to V-T-group pole exchange in t-channel, has [5] an electromagnetic form:

$$M^{V-T}_{qq}=a^2\,\bar q_3\gamma^\mu q_1\,\bar q_2\gamma_\mu q_4 \qquad (2.2)$$

For trajectories of pseudoscalar (P) group (π, B - trajectories) the following interaction is predicted [5] :

$$M^{P}_{qq} = 2a^{2}\bar{q}_{3}\gamma^{5}q_{1}\bar{q}_{2}\gamma^{5}q_{4} \tag{2.3}$$

The hadron wave functions in initial state have an SU(6)-nonrelativistic structure:

$$\Psi^{h}_{in} = \Psi^{h}_{SU(6)} \tag{2.4}$$

As a result of interaction the hadron acquires a final transverse momentum $\vec{q}_{\perp}(t' = -\vec{q}_{\perp}^{\,2})$. The analysis show [6] that in this case the SU(6)-nonrelativistic hadron structure in final state is broken, namely

$$\Psi^{h}_{f} = V(\vec{q}_{\perp})\,\Psi^{h}_{SU(6)} \tag{2.5}$$

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

$$V_{h\to q\bar{q}}(\vec{q}_{\perp}) = 1 + \frac{i\varepsilon_{em}q_{e}}{4m_{q}}(\sigma_{b} - \sigma_{a})m \tag{2.6}$$

For three-quark states

$$V_{h\to 3q}(\vec{q}_{\perp}) = 1 + \frac{i\varepsilon_{em}q_{e}}{6m_{q}}(\sigma_{b} + \sigma_{c} - \sigma_{a})m \tag{2.7}$$

(In formulae (2.6) and (2.7) m_q is the constituent quark mass, the " a " quark being considered active). One can see from (2.6) and (2.7) that helicity is not conserved in hadron-quark vertices. This leads to the hadron-hadron helicity-flip transitions even in the case of nonflip interaction (2.2) at a quark level.

Using the wave functions (2.4), (2.5) and the qq-interaction (2.2), one can obtain predictions for various helicity residues of Regge poles of V-T-group. Thus, for spin nonflip diagonal transitions we have:

$$G^{a\alpha a}_{\lambda_a \lambda_a} = \frac{a}{\sqrt{2}}\left(N^a_u + \sigma_\alpha N^a_{\bar u} + (-1)^{I_\alpha} N^a_d + \sigma_\alpha (-1)^{I_\alpha} N^a_{\bar d}\right) \tag{2.8}$$

$\alpha = \rho\ ,\ \omega\ ,\ A_2, f$ - trajectories,

$$G^{a\beta a}_{\lambda_a \lambda_a} = a\left(N^a_s + \sigma_\beta N^a_{\bar s}\right) \tag{2.9}$$

$\beta = \varphi,\ f'$ - trajectories,

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

Relations (2.8) and (2.9) were obtained earlier in Ref. [4] on the basis of planar diagram accounting. Authors of [4] noted that the derived relations correspond to qq-interaction of electromagnetic type.

Analogous transitions with the change of strangeness have the form:

$$G^{a\gamma b}_{\lambda_a \lambda_a} = a\left(\sqrt{N^a_d N^b_s} + \sqrt{N^a_{\bar s} N^b_{\bar d}}\right) \tag{2.10}$$

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

Relations between spin-flip residues describing pseudoscalar-vector transitions (P → V) are as follows:

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

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

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

$$G^{P\gamma V}_{0\;1} = \frac{a}{2\sqrt{2}\,m_q}\left(\sqrt{N^P_d N^V_s} + \sqrt{N^P_{\bar{s}} N^V_{\bar{d}}}\right) \tag{2.11}$$

For the spin-flip coupling of reggeons with baryons $(1/2)^+$ we have:

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

$$- 3 Y_B I^3_B \left(N^B_u - (-1)^{I_\alpha} N^B_d\right)\Big] \tag{2.12}$$

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

where Y_B and I^3_B are hypercharge and isospin projection.

Predictions for strange pole residues (K^*, K^{**}) are listed in Table 1.

As to the spin-flip vertices of coupling of V-T-group reggeons with vectors, they are zero in AQM.

Table 2 lists residues describing octet (B) → decuplet (B^*) transitions. For these transitions $G^{B\lambda B^*}_{1/2\;3/2} = \sqrt{2}\;G^{B\lambda B^*}_{1/2\;-1/2}$ and $G^{B\lambda B^*}_{1/2\;1/2} = 0$.

3. Relations Between Differential Cross Sections of Binary Processes.

V-T - Group Contributions.

Presented in the previous section relations between the helicity residues $G^{a\alpha\xi}_{\lambda_a\lambda_\xi}$ of V-T-group poles allow one to obtain numerous relations between differential cross sections of the processes in which natural (σP =+1) t-channel exchanges dominate. Thus, for spin-flip parts of $aN \to bN$ and $aN \to b\Delta$ processes from (2.12) and Table 1 the following predictions are obtained:

$$\frac{d\sigma^f}{dt'}(\pi^+ p \to \pi^0 \Delta^{++}) \Big/ \frac{d\sigma^f}{dt'}(\pi^- p \to \pi^0 n) = 3/2 \tag{2.1a}$$

$$\frac{d\sigma^f}{dt'}(\pi^+ p \to \eta \Delta^{++}) \Big/ \frac{d\sigma^f}{dt'}(\pi^- p \to \eta n) = 3/2 \tag{2.1b}$$

$$\frac{d\sigma^f}{dt'}(K^+ p \to K^0 \Delta^{++}) \Big/ \frac{d\sigma^f}{dt'}(K^- p \to \bar{K}^0 n) = 3/2 \tag{2.1c}$$

$$\frac{d\sigma^{+f}}{dt'}(\pi^+ p \to \omega \Delta^{++}) \Big/ \frac{d\sigma^{+f}}{dt'}(\pi^- p \to \omega n) = 3/2 \tag{2.1d}$$

The (+) symbol denotes a cross section corresponding to a contribution of t-channel peculiarities with natural parity $\frac{d\sigma^+}{dt} = (\rho_{11} + \rho_{1-1})\frac{d\sigma}{dt}$

In Fig.1 experimental differential cross sections of processes $\pi^+ p \to \pi^0 \Delta^{++}$, $\pi^+ p \to \eta \Delta^{++}$, $K^+ p \to K^0 \Delta^{++}$ and $(\pi^+ p \to \omega \Delta^{++})^+$ are compared with cross sections of $\pi^- p \to \pi^0 n$, $\pi^- p \to \eta n$, $K^- p \to \bar{K}^0 n$ and $(\pi^- p \to \omega n)^+$, respectively, multiplied by 3/2. One can see a good agreement of the relations between the cross sections with the value of 3/2 in a large region of transferred momenta.

This fact either indicates that in reality the relations (2.1) take place not only between spin-flip parts of cross sections but also between nonflip ones (remind that in AQM $G^{N\alpha^{V-T}\Delta}_{1/2\ \ 1/2} = 0$) or testifies to dominancy of spin-flip amplitudes in $N \xrightarrow{\alpha^{V-T}} A \ (A = N, \Delta)$ transitions at all t. The available measurement accuracy does not allow one to choose between these versions.

For processes $PB \to PB'$ with t-channel strange boson exchange the following relation is predicted:

$$\frac{d\sigma^f}{dt'}(K^-p \to \pi^- \Sigma^{+*}) \Big/ \frac{d\sigma^f}{dt'}(K^-p \to \pi^- \Sigma^+) = 2 \qquad (3.1e)$$

(in the pole approximation, reactions in (3.1e) are determined by contributions of K^* and K^{**} -trajectories).

Fig.2 presents experimental differential cross section of $K^-p \to \pi^- \Sigma^{+*}$ process and data on $K^-p \to \pi^- \Sigma^+$ process, multiplied by 2 . One can see that the ratio of the differential cross sections is in poor agreement with the ratio (3.1e).

The processes $NN \to B\Delta \; (B = N, \Delta)$ at sufficiently high energies ($P_{lab} \geqslant$ 100 GeV/c) are determined by contributions of V-T-group poles (at lower energies the contribution of π -pole dominates [7]).

For reactions $pp \to \Delta^{++}n$ and $pp \to \Delta^{++}\Delta^0$ in this case is predicted:

$$\sigma(pp \to \Delta^{++}\Delta^0) \Big/ \sigma(pp \to \Delta^{++}n) \qquad (3.1f)$$

Fig.2 shows that the ratio of experimental cross sections of these reactions at $\sqrt{S} \geqslant 20$ GeV is in good agreement with (3.1f).

Vertices (2.8), (2.9) and (2.11) of interaction of V-T-group Regge poles with mesons predict simple relations between pseudoscalar-pseudoscalar ($P \to P$) and pseudoscalar-vector ($P \to V$) transitions (in $P \to V$ transitions the residues $G_0^{P\alpha^{V-T}}{}_0^{V}$ are zero owing to P-parity conservation):

$$\frac{d\sigma^+}{dt'}(\pi^+p \to \omega\Delta^{++}) = \frac{|t'|}{4m_q^2}\,\frac{d\sigma}{dt'}(\pi^+p \to \pi^0\Delta^{++}) \qquad (3.2a)$$

$$\frac{d\sigma^+}{dt'}(\pi^- p \rightarrow \omega n) = \frac{|t'|}{4m_q^2}\,\frac{d\sigma}{dt'}(\pi^- p \rightarrow \pi^0 n) \tag{3.2b}$$

$$\frac{d\sigma^+}{dt'}(K^- p \rightarrow \bar{K}^{0*} n) = \frac{|t'|}{4m_q^2}\,\frac{d\sigma}{dt'}(K^- p \rightarrow \bar{K}^0 n) \tag{3.2c}$$

$$\frac{d\sigma^+}{dt'}(K^+ p \rightarrow K^{0*}\Delta^{++}) = \frac{|t'|}{4m_q^2}\,\frac{d\sigma}{dt'}(K^+ p \rightarrow K^0\Delta^{++}) \tag{3.2d}$$

The quark mass m_q enters as a parameter to relations (3.2). A numerical value of m_q in the framework of our approach was determined in Ref. [8] from the analysis of partial widths of boson resonances (asymptotic planarity region). It proved to be

$$m_q = 415 \pm 15 \text{ MeV} \tag{3.3}$$

Fig.3 presents diagrams of experimental data illustrating a good agreement of relations (3.2a)-(3.2c) with experiment. Ibidem, we give a comparison between the experiment and our prediction for the strange exchange processes:

$$\frac{d\sigma^+}{dt'}(\pi^- p \rightarrow K^{0*}\Lambda) = \frac{|t'|}{8m_q^2}\,\frac{d\sigma}{dt'}(\pi^- p \rightarrow K^0\Lambda) \tag{3.4}$$

One can see that relation (3.4) is fulfilled poorly experimentally.

4. Contribution of Pseudoscalar Group Reggeons.

Contrary to processes which are determined by contributions of V-T-group reggeons, those proceeding owing to exchange by other trajectories (π^-, B^-, A_1^- etc.) are studied less in detail experimentally. In our approach [5], the interaction of P-group reggeons with quarks has a form of ([illegible]). In this case AQM predicts the ratio of cross sections of $ap \to b\Delta^{++}$ and $ap \to bn$ processes equal to 24/25. In particular

$$\frac{d\sigma^-}{dt'}(\pi^+ p \to \rho^\circ \Delta^{++}) \Big/ \frac{d\sigma^-}{dt'}(\pi^- p \to \rho^\circ n) = \frac{24}{25} \tag{4.1a}$$

$$\frac{d\sigma^-}{dt'}(\pi^+ p \to \omega \Delta^{++}) \Big/ \frac{d\sigma^-}{dt'}(\pi^- p \to \omega n) = \frac{24}{25} \tag{4.1}$$

where $\frac{d\sigma^-}{dt} = (\rho_{11} - \rho_{1-1} + \rho_{00})\frac{d\sigma}{dt}$ is a part of differential cross section corresponding to t-channel exchange of unnatural spin-parity.

As distinct from AQM, the dispersion sum rules (DSR) for reggeon scattering on particles predict [7] for relations (4.1) the values 3/2 instead of 24/25. A comparison of theoretical predictions with experiment (Fig.4) shows that the DSR predictions for coupling of baryons with pseudoscalar reggeons work appreciably better than the AQM ones. As to relations (3.1f), here calculations within AQM and DSR coincide.

5. Nonplanar Contributions.

The implication of the asymptotic planarity hypothesis allows one to estimate within the framework of our approach the contributions of nonplanar corrections to amplitudes of binary spin processes.

For that purpose, we shall use the parametrization of function $a(t)$ in the definition of residues $G^{a\alpha b}_{\lambda_a \lambda_b}(t)$ in the form it was applied to the analysis of boson resonance decays [9] in the region of positive t

$$a^2(t) = \frac{a_o^2}{\Gamma[\alpha(t)]} \tag{5.1}$$

where a_0 is a constant defined from $\rho \to 2\pi$ decay. Using relations between $G^{a\alpha\beta}_{\lambda_\alpha \lambda_\beta}(t)$, parametrization of amplitude $M^{\rho\rho}(s,t)$ in the form of (2.1) and (5.1) and also the values of parameters a_0 and m_q derived from the boson resonance decay widths, we can obtain predictions for contributions of planar diagrams to the cross sections of binary processes at $t < 0$. The deviation of experimental data from these predictions seems natural to be explained by ignored contribution of nonplanar diagrams (cuts, etc.) which, according to the asymptotic planarity hypothesis, are small in the region of positive t. Figs. 5, 6 show predictions for planar contributions to differential cross sections of processes $\pi^+ p \to \pi^0 \Delta^{++}$, $\pi^- p \to \pi^0 n$, $K^- p \to \bar{K}^0 n$, $K^- p \to \pi^- \Sigma^+$, $K^- p \to \pi^- \Sigma^{+*}$ and $\pi^+ \pi^- \to \pi^0 \pi^0$. Errors due to experimental uncertainty of quantities a_0 and m_q are not given on the prediction curves.

In our approach the planar part of the $\pi^+ p \to \pi^0 \Delta^{++}$ process is described by the spin-flip contribution of the ρ-pole. Fig.5 demonstrates a good description of the reaction differential cross section at $p_{lab} = 16$ GeV/c by the planar amplitudes. Ibidem we give a total contribution of our predicted spin-flip and spin nonflip amplitudes to the differential cross section of the $\pi^- p \to \pi^0 n$ process. There is a considerable disagreement with the experiment. This fact, in addition to that both relation (3.1a) for spin-flip contributions and the description of the $\pi^+ p \to \pi^0 \Delta^{++}$ process are in good agreement with the experiment, indicates that for $\pi^- p \to \pi^0 n$ our predicted nonflip amplitude, contrary to the flip one, is substantially renormalized by nonplanar corrections. The experimental confirmation of relation (3.2a) allows one to apply this conclusion also to natural contributions in the process $\pi^- p \to \omega n$.

In Ref. [4], in the analysis of differences of hadronic cross sections of πN, KN, NN and $N\bar{N}$ -scattering, it was mentioned that contributions of cuts in diagonal over spin variables elastic scattering amplitudes at $t = 0$ are highly considerable and depend weakly upon the quark composition of particles. Numerical estimates within our approach show that contributions of the Regge vector poles (ρ, ω) to the nonflip elastic amplitudes of the cited processes are renormalized by nonplanar corrections by (50-70) % in a wide energy range (20 - 200 GeV).

Our analysis testifies to strong dependence of nonplanar contributions on hadron spin states. In particular, the nonflip amplitude corresponding to ρ-pole exchange is renormalized by nonplanar corrections much stronger that the flip one. The comparison of our prediction for the planar part of $\pi\pi$-scattering differential cross section with data of one-pion-exchange model (OPER) supports the above statement (see Fig.5).

Fig.6 presents our predictions for planar contributions to the scattering processes of the strange sector particles. In the pole approximation, the cross section of the $K^+p \to K^0\Delta^{++}$ process is determined by ρ- and A_2-trajectories contributions. The predictions for the ρ and A_2 contributions to the spin-flip part of the differential cross section are compared with experimental data at p_{lab} = 13 GeV/c. One can see that the disagreement between the predictions and experiment is due mainly to the A_2-pole contribution. Taking into account a good description of the $\pi^+p \to \pi^0\Delta^{++}$ process merely by the ρ-pole (see Fig.5), one can conclude that the A_2-pole contribution, contrary to ρ, is renormalized by nonplanar corrections much stronger. Such a conclusion agrees well with the "asymptotic planarity" hypothesis, according to which nonplanar corrections to the Regge amplitude must grow with moving away along t from the resonance region of the Regge trajectory considered. Indeed, the nearest resonance of the ρ-trajectory ρ(770) is much nearer to the considered region of negative t than that of the A_2-trajectory (A_2(1320))

Presented in Fig.6 comparison of contributions of K^* and K^{**} poles in the $K^- p \to \pi^- \Sigma^+$ and $K^- p \to \pi^- \Sigma^{+*}$ reactions with experimental data also confirms the fact that nonplanar corrections in the considered region $0 < -t < 1$ GeV^2 renormalize the tensor trajectories much stronger that the vector ones.

Conclusion.

The study of the binary spin processes within DTE is of great interest for the analysis of contributions of various topological objects of DTE to hadron amplitudes and their role in formation of spin effects.

In Refs. [5, 6], there were studied both the spin structure of qq-scattering planar amplitude within the quark-gluon multiperipheral mechanism and the role of the hadron wave functions in formation of hadron spin phenomena.

The results of [5] and [6] are applied in the present work to analyze contributions of the planar diagrams to the binary spin processes at high energies.

Numerous relations between differential cross sections of various spin processes are obtained with the use of predicted in [5] spin structures of interaction of reggeons with quarks and AQM with the SU(6)-classification of hadrons. Our predictions for relations between processes with dominating nonstrange t-channel exchanges of natural spin-parity are in good agreement with experiment. A comparative analysis of AQM and DSR predictions is carried out for processes with unnatural exchanges in the t-channel. It is shown that the DSR predictions are in better agreement with experimental data.

The fact that relations between cross sections obtained in the planar approximation are confirmed experimentally does not imply smallness of nonplanar corrections. The latters can be such that their contributions would not spoil relations of planar approximation. In the present work we have estimated contributions of nonplanar diagrams to the binary spin processes based on the "asymptotic planarity" hypothesis. The analysis shows a strong dependence of nonplanar contributions not only on kinematical variables, but also on spins, helicity states and quark composition of interacting particles. For a detailed analysis of this dependence, more precise polarization measurements at high energies are needed.

It should be noted, in addition, that a more correct quantitative analysis of nonplanar contributions requires calculation of coupling vertices of reggeons with hadrons in the framework of a more realistic, compared to nonrelativistic, quark model. As is shown by preliminary calculations within realistic quark model suggested in Ref. [10], the account of relativistic corrections due to relative motion of quarks in hadrons leads to a change of spin-flip vertices $N\alpha_i N$ and $N\alpha_i \Delta$ within 20 %. However the relation between them is practically unchanged. At present, within the quark model [10], calculations of $B\alpha_i B$ vertices including strange particles are carried out.

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Table 1

Predictions for $G^{B\gamma B'}_{1/2\ -1/2}$, $\gamma = K^{0*}$. K^{0**} .

$B \xrightarrow{\gamma} B'$	$\frac{m_q}{a} G^{B\gamma B'}_{1/2\ -1/2}$
$P \to \Sigma^+$	$1/3$
$\Sigma^- \to \Xi^-$	$2/3$
$\Lambda \to \Xi^0$	0
$n \to \Lambda$	$1/\sqrt{6}$

Table 2

Predictions for $\frac{m_q}{a} G^{B\lambda B^*}_{1/2\ \ 3/2}$.

λ $B \xrightarrow{\lambda} B^*$	ω, f	ρ^0, A_2^0	φ, f'	K^{0*}, K^{0**}
$P \to \Delta^+$		$-1/\sqrt{3}$		
$\Sigma^+ \to \Sigma^{+*}$	$-1/2\sqrt{3}$	$-1/2\sqrt{3}$	$-1/\sqrt{6}$	
$\Xi^0 \to \Xi^{0*}$	$1/2\sqrt{3}$	$1/2\sqrt{3}$	$1/\sqrt{6}$	
$P \to \Sigma^{+*}$				$1/\sqrt{6}$
$\Sigma^+ \to \Delta^+$				$1/\sqrt{6}$
$\Lambda \to \Sigma^{0*}$		$-1/2$		
$\Sigma^- \to \Xi^{-*}$				$-1/\sqrt{6}$
$\Xi \to \Omega^-$				$-1/\sqrt{2}$
$\Lambda \to \Xi^{0*}$		$1/2$		

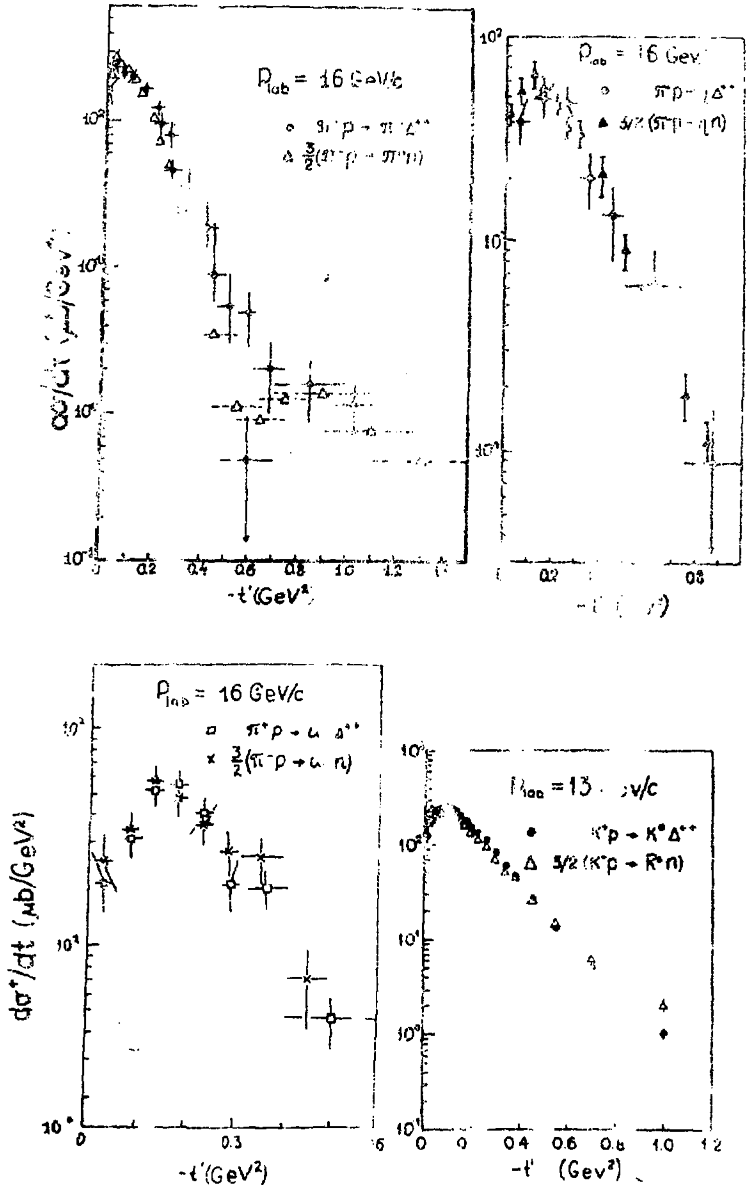

Fig.1. Comparison of relations (3.1a)-(3.1d) with experiment. Data are taken: for $\pi^+ p \to \pi^0 \Delta^{++}$ and $\pi^+ p \to \eta \Delta^{++}$ from [11]; for $\pi^- p \to \pi^0 n$ from [12] (data were extrapolated to $P_{lab} = 16$ GeV/c); for $\pi^- p \to \eta n$ from [13]; for $K^+ p \to K^0 \Delta^{++}$ and $K^- p \to \bar{K}^0 n$ from [14]; for $\pi^+ p \to \omega \Delta^{++}$ from [15]; for $\pi^- p \to \omega n$ from [16] (extrapolated to $P_{lab} = 16$ GeV/c).

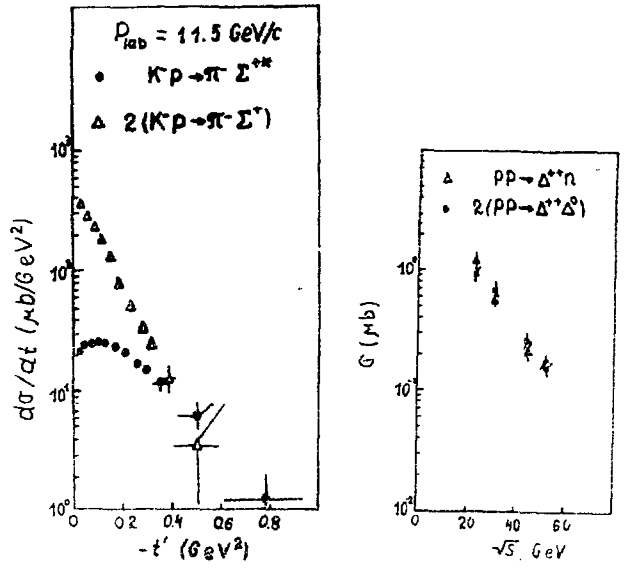

Fig.2. Comparison of relations (3.1e), (3.1f) with experiment. Data are taken: for $K^-p \to \pi^-\Sigma^+$ and $K^-p \to \pi^-\Sigma^{+*}$ from [17] ; for $pp \to \Delta^{++}\Delta^0$ from [18] ; for $pp \to \Delta^+ n$ from [19] .

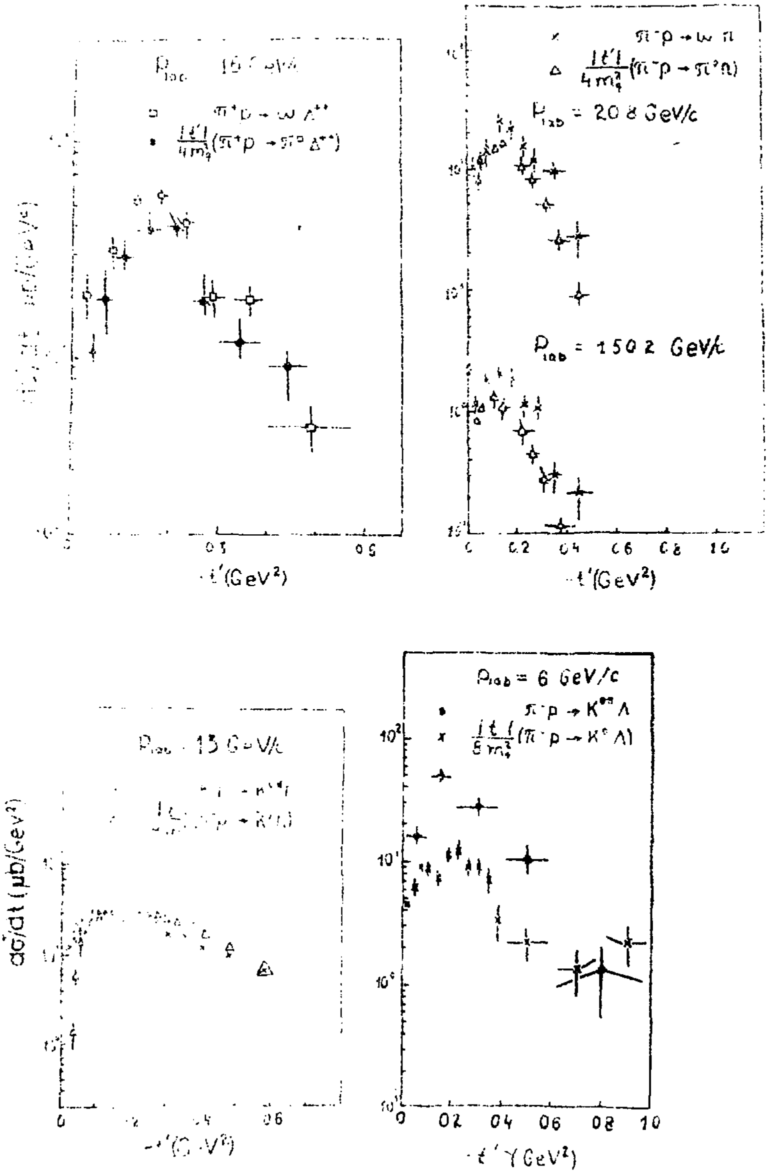

Fig.3. Experimental check of relations (3.2a)-(3.2c) and (3.4). Data are taken: for $K^-p \to \bar{K}^{0*}n$ from [20] : for $\pi^-p \to K^0\Lambda$ and $\pi^-p \to K^{0*}\Lambda$ from [21] .

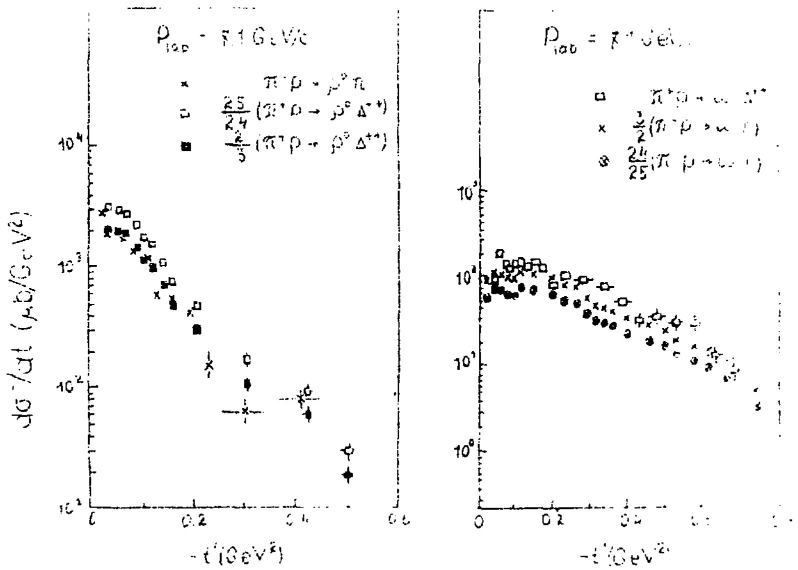

Fig.4. Comparison of relations (4.1a), (4.1b) with experimental data. Data are taken: for $\pi^+p\to\rho^0\Delta^{++}$ and $\pi^+p\to\omega\Delta^{++}$ from [22]; for $\pi^-p\to\rho^0 n$ from [23]; for $\pi^-p\to\omega n$ from [24].

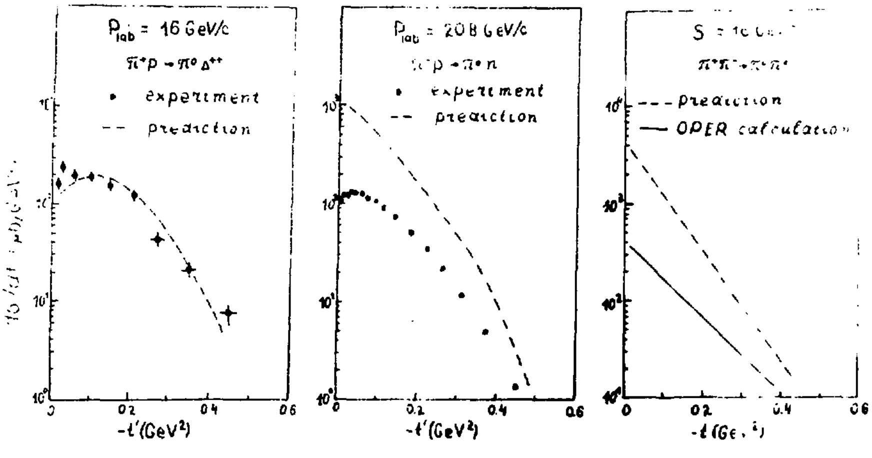

Fig.5. Predictions for planar contributions to differential cross sections of the processes $\pi^+p\to\pi^0\Delta^{++}$, $\pi^-p\to\pi^0 n$ and $\pi^+\pi^-\to\pi^0\pi^0$. OPER predictions for the latter are taken from [25].

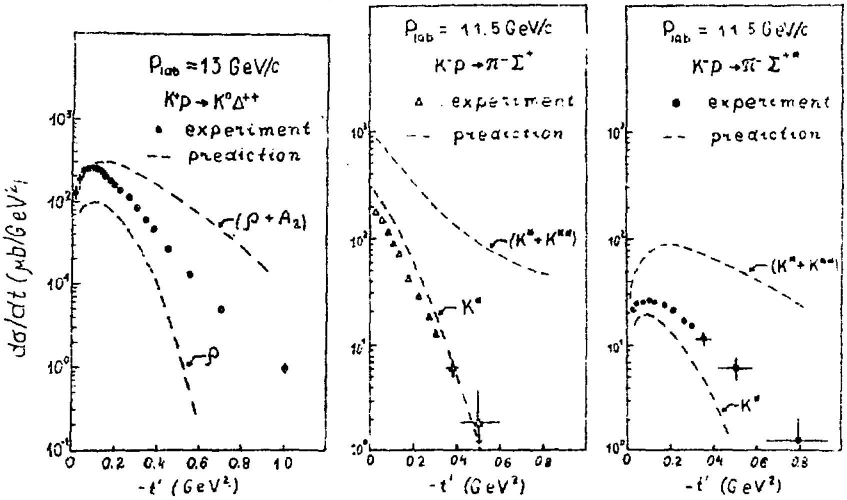

Fig.6. Predictions for planar diagram contributions to differential cross sections of strange particle scattering.

REFERENCES

1. Veneziano G. Some aspects of unified approach to gauge, dual and Gribov theories. - Nucl.Phys., 1976, v.B117, N.2, p.519-545.
2. Capella A., Sukhatme U., Tran-Thanh-Van J. et al. Soft multihadron production from partonic structure and fragmentation functions. - Zeit. fur Phys., 1980, v.C3, p.329-337;

   Cohen-Tannoudji G., Hassouoni A.El., Kalinowski J., Peschanski R. A quark parton model from dual topological unitarization. - Phys.Rev., 1979, v.D19, N.11, p.3397; Partons at low $p_\perp$. - Phys.Rev., 1980, v.D21, N.9, p.2699-2705.
3. Chew G.F., Rozenzweig C. Dual topological unitarization: an ordered approach to hadron theory. - Phys.Rep., 1978, v.C41, N.5, p.263-327.
4. Kaidalov A.B., Volkovitsky P.E. The differences of hadron cross sections and the residues of secondary reggeons in the quark-gluon model of strong interactions. - Yad.Fiz., 1982, v.35, N.5, p.1231-1239.
5. Grigoryan A.A., Ivanov N.Ya., Kaidalov A.B. Spin in the quark-gluon picture of strong interactions. Secondary Regge-trajectories. - Yad.Fiz., 1982, v.36, N.6, p.1490-1495.
6. Aznauryan I.G., Grigoryan A.A., Ter-Isaakyan N.L. How to deal with spin in the quark model at high energies and small momentum transfers. - Phys. Lett., 1983, v.126B, N.3/4, p.271-274.
7. Grigoryan A.A., Kaidalov A.B. Superconvergent dispersion sum rules and structure of vertices of interaction of I=1 reggeons with baryons. - Yad. Fiz., 1979, v.30, p.1636.
8. Григорян А.А., Иванов Н.Я. Модель для распадов бозонных резонансов с произвольным спином. ЯФ,1986, т.43,№ 3, с.693.

9. Kaidalov A.B., Volkovitsky P.E. The partial widths of boson resonances in the quark-gluon model of strong interactions. - Yad.Fiz., 1982, v.35, N.6, p.1556-1562.

10. Aznauryan I.G., Bagdasaryan A.S., Ter-Isaakyan N.L. Relativistic quark-model in the infinite momentum frame and static characteristics of nucleons. - Phys.Lett., 1982, v.112B, N.4/5, p.393-396.

11. Honecker R., Laven H., Becker L. et al. Study of the reactions $\pi^+ p \to \pi^0 \Delta^{++}$ (1236), $\eta\Delta^{++}$(1236) and $\eta'\Delta^{++}$(1236) at 16 GeV/c. - Nucl.Phys., 1977, v.B131, N.2/3, p.189-209.

12. Barnes A.V., Mellema D.J., Tollestrup A.V. et al. Pion charge-exchange scattering at high energies. - Phys.Rev.Lett., 1976, v.37, N.2, p.76-80.

13. Dahl O.I., Johnson R.A., Kenney R.W. et al. Reaction $\pi^- p \to \eta n$ at high energies. - Phys.Rev.Lett., 1976, v.37, N.2, p.80-83.

14. Brandenburg G.W., Carnegie R.K., Cashmore R.J. et al. Differential cross sections for the reactions $K^- p \to \bar{K}^0 n$, $K^- p \to \bar{K}^0 \Delta^0$ and $K^+ p \to K^0 \Delta^{++}$ at 13 GeV/c. - Phys.Rev., 1977, v.15, N.3, p.617-627.

15. Grassler H., Honecker R., Laven H. et al. Study of reaction $\pi^+ p \to \omega \Delta^{++}$ (1236) at 16 GeV/c. - Nucl.Phys., 1976, v.B115, N.3, p.365-385.

16. Dahl O.I., Johnson R.A., Kennei R.W. et al. Reaction $\pi^- p \to \omega n$ at momenta from 20 to 200 GeV/c. - Phys.Rev.Lett., 1977, v.38, N.2, p.54-57.

17. Baker P.A., Chima J.S., Dornan P.S. et al. Experimental test of exchange degeneracy in hypercharge exchange reactions at 7 and 11.5 GeV/c. - Preprint SLAC-PUB-2169, 1978, p.1-16.

18. Goggi G., Cavalli-Sforza M., Conta C. et al. Analysis of the charge-exchange reaction $pp \to (p\pi^+)(p\pi^-)$ and of $\Delta^{++}\Delta^0$ production at the CERN ISR. - Nucl.Phys., 1978, v.B143, N.2, p.365-374.

19. De Kerret H., Nagy E., Orr S.R. et al. A study of the charge-exchange reaction $pp \to n\Delta^{++}$ (1236) at ISR energies. - Phys.Lett., 1977, v.69B, N.3, p.377-387.

20. Estabrooks P., Carnegie R.K., Brandenburg G.W. et al. Charged - $K^*(890)$ production at 13 GeV/c. - Phys.Rev., 1978, v.D17, N.3, p.658-663.

21. Crennell D.J., Cordon H.A., Kwan-Wu Lai, Scarr J.M. Two-body strange-particle final states in $\pi^- p$ interactions at 4.5 and 6 GeV/c. - Phys. Rev., 1972, v.D6, N.5, p.1220-1254.

22. Chung S.U., Protopopescu S.D., Eisner R.L., Flatte S.M. Study of vector meson + baryon resonance production in $\pi^+ p$ interactions at 7.1 GeV/c.- Phys.Rev., 1975, v.D12, N.3, p.693-719.

23. Matthews J.A.J., Prentice J.D., Yoan T.S. et al. Regge analysis of ρ^0 production in πN charge exchange channels at 7 GeV/c. - Nucl.Phys., 1971, v.B32, N.2, p.366-380.

24. Shaevitz M.H., Reay N.W., Reibel K., Stanton N.R. High statistics study of ω production. - Phys.Rev.Lett., 1976, v.36, N.1, p.8-11.

25. Боресков К.Г., Кайдалов А.Б., Пономарев Л.А. Реджевская параметризация амплитуд $\pi\pi$-рассеяния. Описание реакции $\pi^- p \to \pi^- \pi^+ n$ в модели OPER , ЯФ, I973, т.I7, № 6, с.I285-I294.

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ПЛАНАРНЫЕ КВАРКОВЫЕ ДИАГРАММЫ И БИНАРНЫЕ СПИНОВЫЕ ПРОЦЕССЫ
(на английском языке, перевод З.Н.Асланян)
Редактор Л.П.Мукаян
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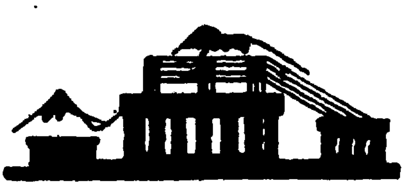

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