PLENARY REPORT

HIGH ENERGY THEORY OF STRONG INTERACTIONS

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Development of strong interaction theory at high energies can be overlooked by following two supplementary directions: surveying the current theoretical approaches and models- on the one hand,and analysing recent experimental results which give us information about the dynamics of strong interaction- on the other hand.This formidable task can be solved only by all the speakers summarizing their efforts in discussions at parallel sessions AI-A5.

The contents of this talk are arranged as follows:

I. General results in QFT
II.Theory of diffraction scattering and the vacuum exchange
III.Regge/quark analysis
IV. High energy scattering in models of QFT
V. Constituent theory of hadron interactions
VI. Power laws
VII. Scaling and similarity laws
VIII. Concluding remarks

I.GENERAL RESULTS IN QFT

I.QFT as a guide to the theory of strong interactions.

The general principles and results of the local QFT are the basis of the most of theoretical constructions and phenomenological analysis in studying strong interaction phenomena at high energies.

One of the most successful methods through the years, was the method of dispersion relations introduced into the QFT by Gell-Mann,Goldberger and Thirring.

In the papers by Bogolubov on the theory of dispersion relations the fundamental idea of scattering amplitude as a unique analytic function of its kinematical variables has been introduced for all the physical channels connected by crossing symmetry relations. This concept proved to be very useful in attempts to understand the existing theoretical schemes and phenomenological approaches as possible approximations to the theory of strong interactions.

Use of the analyticity of amplitudes as functions of momentum transfer related to the short range character of nuclear forces has been particularly fruitful in the study of strong interactions at high energies. First of all, this has led to the derivation of a number of fundamental asymptotic relations and bounds on the cross sections. This concept has also served as an adequate tool for introducing the Regge ideas to QFT and for developing the quasi-optical picture of the high energy hadron scattering processes.

The most crucial problem of the field theory approach to the theory of strong interactions nowdays is the problem of consistent incorporation of the idea of the composite quark structure of hadrons.

2. Asymptotic bounds and theorems

As is well known, analytic properties of scattering amplitudes in transferred momentum lead to the ultimate relation between high energy behaviour and t-channel singularities. A number of new results have been recently found in that direction.

In the paper by Logunov,Mestvirishvili et al.[1] submitted to this conference, the question has arisen:"Do u-channel singularities in the complex t-plane influence the high energy behaviour of the forward scattering cross sections?" The basic assumptions made in this paper are as follows:

I. Existence of dispersion relations in t at $s > s_{thr.}$ with a finite number of subtractions.
2. Polynomial boundness at large s.

The answer given by the authors is no! Namely,the relative contribution of the u-channel singularities is bounded asymptotically by

$$\left|\frac{T_u(s,\theta=0)}{T_t(s,\theta=0)}\right| \lesssim \frac{\ln^2 s}{s}$$

in the case of the non-decreasing total cross sections.

This result which is based essentially on the dispersion relations and unitarity gives a rigorous extension of the principle of nearest singularity dominance from the high energy behaviour of absorptive part:

$$\mathrm{Im}\, T(s,t=0) = s\,\sigma_{tot}.$$

to the complete amplitude

$$T(s,t=0) = s\left(\frac{d\sigma}{dt}\right)^{\frac{1}{2}}_{t=0} \quad .$$

The result has been improved in the work by Rcheulishvili and Samokhin[2] where the more restricted domain of analyticity in the complex Cosθ-plane was considered (see Fig.I).

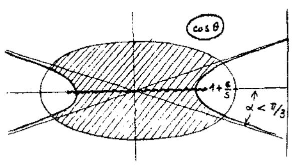


Fig.1.The analyticity domain in CoS -plane as being assumed in the paper[2] (dashed region).

It is argued that scattering in the forward (backward) cones at high energies is determined by singularities which lie in the right(left) half-planes of Cosθ.

Interesting results are found in the recent paper[3/] titled as "Why is the diffraction peak a peak?" An attempt is made here to find rigorous and general (as much as possible) answers to a number of questions concerning the asymptotic characteristics of the diffraction peak, namely, whether:

(?) the high energy differential cross section has a maximum exactly in the forward direction;

(??) the slope of the diffraction peak is determined by the absorptive part of scattering amplitude;

(???) the slope parameter is really bounded by $\log^2 s$, etc.

The positive answers to all the questions listed above were found in this paper. Moreover, it was pointed out that the oscillating cross sections are allowed, that the real part of scattering amplitude should not be small and so on.

In two papers by Mnatsakanova and Vernov(jr.)[4/] submitted to this conference, a justification of a number of rigorous asymptotic bounds on scattering amplitudes and cross sections is given which are effective on finite energy intervals.

An analysis of analytic properties of scattering amplitudes in local QFT and a review of available axiomatic restrictions on high energy hadron scattering are presented in papers[5/].

2. Quasi-local dispersion relations

Evaluation of the real part of a scattering amplitude in terms of an integral over the imaginary part by means of the dispersion relations is a formidable task because of the essentially non-local character of these relations. The quasi-local form of these relations or the derivative analyticity relations have attracted general attention in the last few years[6/]. It was found that the DAR provides a simple and effective approximation for the conventional dispersion relations of the real part calculations at high energies if the threshold and resonance effects are unimportant. Moreover, it was proposed to use the DAR as a tool for complete reconstruction of a scattering amplitude from experimental data at asymptotic energies.

In the paper by V.A.Mescheryakov et al.[7/] submitted to this conference, another form of quasi-local dispersion relations was presented which is based on the method of uniformization of scattering amplitude at high energies(or UM). It was proposed to use as a uniformization variable the eq.

$$w(\nu)= \frac{I}{\pi} \text{ arc } \sin\nu = \frac{I}{2} + \frac{i}{\pi}\ln|\nu+\sqrt{\nu^2-I}|,$$

where $\nu=(s-u)/4m$ and $\mu=I$. At $\nu\gg I$, $w(\nu)\sim -\frac{I}{i\pi}(\ln s - i\pi/_2)$ which points to complex logarithmic structure of the Riemann surface of a forward scattering amplitude as a function of the energy variable ν.

The function $w(\nu)$ gives a mapping of the whole Riemann surface of a scattering amplitude on the complex w-plane by a system of strips(Fig.2) The image of the physical sheet is the strip: $-\frac{1}{2} < \text{Re } w < \frac{1}{2}$. The forward scattering amplitude determined by the formula $\text{Im}F_\pm = (\sigma \pm \bar{\sigma})$ has the kinematical poles at $w = n+\frac{1}{2}$, so as $F_\pm = f_\pm / \sqrt{\nu^2-I} = \frac{f\pm(w)}{i\cos \pi w}$

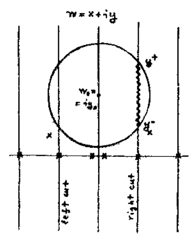


Fig.2. The map of the Riemann surface of the forward scattering amplitude.
x - position of poles.

The analyticity and the symmetry relations

$$F_\pm(w) = \pm F_\pm(-w)$$
$$F^*_\pm(w) = -F_\pm(w^*)$$

lead to the generalization of DAR:

$$F^*_\pm(w) = \mp e^{-2x\frac{d}{dw}} F_\pm(w), \quad (w=x+iy).$$

The method has used as a tool for analysis of experimental data. Assume that $F= u+$ if is a holomorphic function within the circle $|w-w_o|\leqslant R$ (see Fig.2) so that $V(x,y)$ is harmonic there, i.e. $\Delta V = (\partial^2_x + \partial^2_y)V = 0$. By the theory of analytic function[8/]

$$F(w) = 2iV\left(\frac{w+w_o}{2}, \frac{w-w_o}{2i}\right) + F^*(w_o).$$

Determining $V(x,y)$ by its decomposition in the convergent (in the circle) series

$$V(x,y)= \sum_{n=I,..} \sum_{m>2n-1} a_m \frac{(-)^{n+I}(m-I)!}{(m+I-2n)!}(y-y_o)^{m+I-2n} \times \begin{cases} \dfrac{x^{2n-2}}{(2n-2)!} & (\text{for } F_+) \\ \dfrac{x^{2n-I}}{(2n-I)!} & (\text{for } F_-) \end{cases}$$

one gets the decomposition of a forward scattering amplitude in powers of $y(\approx \log {}^s/_\pi)$ convergent in some finite interval of energies:

$$y^- \leqslant y \leqslant y^+ \; ; \; y^\pm \approx \frac{I}{\pi} \log 2\nu_\pm = y_o \pm (R^2-\tfrac{1}{4})^{\frac{1}{2}}.$$

By fitting experimental data on πp, Kp and pp-scattering (with the only parameters $a^{+}_{I,2,3}$ and a^{-}_{I} and $c=F_{-}(iy_0)$ the authors have tested a number of quark relations among the total cross sections. It was found that Lipkin's sum rule

$$^{2}/_{3}\sigma_{tot}(\pi^{-}p)+{}^{1}/_{3}\sigma_{tot}(\pi^{+}p) = {}^{1}/_{2}\sigma_{tot}(K^{+}p)+{}^{1}/_{3}\sigma_{tot}(pp)$$

has to be hold with 3% accuracy from P=I0 GeV/c up to $I0^3$ GeV/c .

TABLE

Test of Lipkin's sum rule(L and R are the left- and right-hand sides of the relation)

	(L)	(R)
p_L (GeV/c)	L (mb)	R (mb)
200	24.14±0.05	23.69±0.07
400	25.05±0.05	24.45±0.08
600	25.83±0.06	25.13±0.10
800	26.48±0.07	25.71±0.12
1000	27.04±0.08	26.23±0.14
1200	27.54±0.09	26.69±0.16
1400	27.99±0.09	27.10±0.18
1600	28.40±0.10	27.48±0.20
1800	28.78±0.11	27.83±0.21
2000	29.13±0.12	28.15±0.23

Works with 3% accuracy from P=I0 up to $I0^3$GeV/c

II. THEORY OF DIFFRACTION SCATTERING AND THE VACUUM EXCHANGE.

I. Models of the fast growth

Five years ago the flattering out of the hadron total cross sections and the growth of σ_{K^+p} with energy have been observed in experiments at IHEP and named "Serpukhov's effect". The foregoing experiments at CERN and FNAL have shown universality of the total cross section energy growth[9].

This effect which is not quite unexpected due to the Froissart theorem known from I96I, did not explain nevetherless, by the popular at that time, the theory of complex angular momenta in its original form. So many different models have appeared, namely: field theory models, quasi-optical models, regge-eikonal models and others, where different approaches in the description of the total cross section energy growth as well as of the whole range of diffraction phenomena were developed.

Notice that a simple and physically lucid description of the cross section energy growth is given in the framework of the hadron scattering quasi-optical picture[I0].

It was known for a long time that the energy dependent smooth local quasi-potential allows one to reproduce the main features of the high energy hadron scattering. The polynomial growth of the strength of interaction depending on the energy leads to the maximal energy growth of a total cross section permitted by the s-channel unitarity [II].

In the papers by Khrustalev and Tyurin [I2] and Tyurin et al. submitted to this Conference, the quantitative description of the total cross section energy growth as well as of other observable quantities of the high energy πN-scattering was given on the basis of the U-matrix method. The U-matrix is related to the scattering amplitude T by the relativistic one-time dynamical equations

$$T = U + \int_{\text{phase volume of real particles}} U \cdot T \, dw$$

proposed by Logunov, Khrustalev, Savrin and Tyurin in I970[I3]. By analytic continuation into the t-channel $U \to \tilde{U}$ and using the Regge-pole expansion for $\tilde{U}_-$, the authors of the paper[I2] developed a method for description of the high energy scattering which allows one to take into account the unitarity in the direct s-channel (by construction). Thus, a good fit to the experimental data is found with polynomially growing $\tilde{U} \sim s^{\alpha}$ where $\alpha > I$ without contradicting the Froissart theorem (see Fig.3).

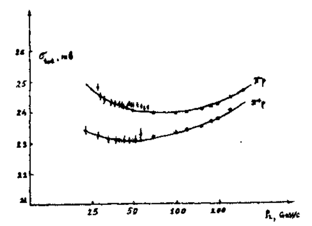


Fig.3.
The total cross-section of $\pi^{\pm}p$ scattering in the U-matrix approach.

One of the first detaild analyses of an assumption that the high energy hadron scattering observed at Serpukhov and also at CERN and FNAL realize the maximal energy growth of the scattering amplitudes, was made in the papers by L.D.Soloviev [I4] and Soloviev and Schelkachev[I5]. The authors introduced there the term "model of the fast growth". Determining the complete scattering amplitude as a sum

$$T = T_{Froissart} + T_{Regge} ,$$

where the "Froissart" part at finite energies has the form

$$T_{Froissart} \sim i\, sR^2 \exp(xt/2) \cdot J_1(Rq)/_{Rq}; \; q=\sqrt{-t}$$

$$R^2 = \rho^2 + R_0^2(s) \; ; \; R_0^2(s) = \frac{I}{M^2} \log^2 s/_{s_0} ,$$

the authors have found a good description of existing experimental data with the universal energy growth for all the hadronic total cross sections (excluding pp-scattering cross sections)

$$\sigma_{tot} \to 2\pi R_0^2 = c \log^2 s/s_0$$

The fit gives c (0.2 ÷ 0.4)mb or for an effective mass of exchange states M≈(I.3 ÷ 3.0) Gev/c^2 (too high as compared with the pion mass). The authors state that B is too small to be observed at available energies due to the kinematical suppressing the $\log^2 s$ term (see Fig.4 a,b- illustrating the fit)

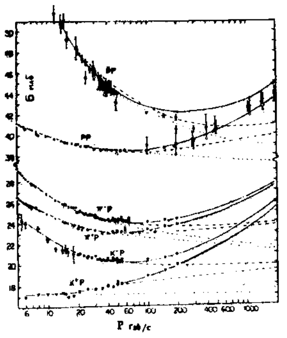


Fig.4a. Total cross sections in the model of "fast growth".

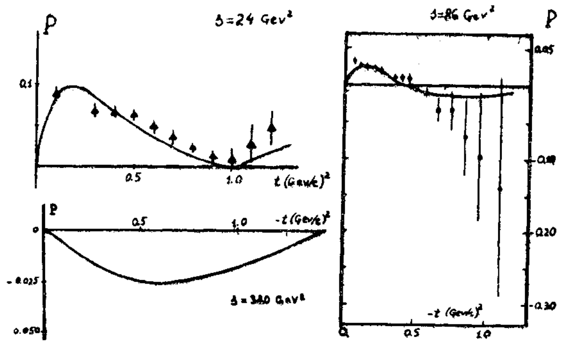


Fig.4b. Polarization in pp-scattering.

An analysis of the high energy hadron scattering in terms of j-plane leading singularity with $\alpha(0)>$ I was performed in the papers by Dubovikov and Ter-Martirossian[I6], Kopeliovich and Lapidus[I7] and others[I8], who used s-channel unitarization by means of eikonal representation.

2.Nature of the vacuum exchange

Idea of the Regge-poles proved to be very fruitful in the analysis of the high energy hadron reactions. There is a clue of complex problems of the Regge-approach still waiting for their solution. One of them is the nature of the vacuum exchange(the Pomeranchuk singularity). From the time when it was postulated in order to explain the gross features of diffraction scattering,especially the miraculous constancy of total cross sections the term "Pomeron" is still an enigma.

This notion is surrounded by a constellation of different effects, such as: self-consistent j-plane singularity or Reggeon field theory(RFT), critical phenomenon in RFT,Goldstone particle, "cylinder"topology contribution in dual theory, multiparton fluctuations, "bag" model (with colored gluon exchange), "glue balls" and many others [I9- 26].

Some of these approaches were discussed at parallel session A5. This rich circle of questions is beyond of scope in our talk and will be discussed by the following speakers(see Kaidalov's talk) Here we only briefly mention some points. In the paper by Sugar et al[20], the Reggeon field theory is studied in zero transverse dimensions,i.e.,at d=0. By means of renormalization group the existence of the infrared stable fixed point is found. It is pointed out that the solution has no bona fide second order phase transition.[2I]

In the paper by Dyatlov[24] a theory of the weak-coupled Pomeron as a Goldstone particle was presented. The bound states of two Pomerons are found in this theory which can be useful in explanation of the diffraction peak structure. Unfortunately,this leads to the non-analyticity in transferred momenta at t=0.

The RFT on a lattice for $\alpha(0)>$I is studied in the paper by Amati et al.[25] Using the low-lying structure of an excitation spectrum the existence of the critical phenomena(second order phase transition) is found which is characterized by the value of α_c more than unity. The final asymptotic picture is that of a grey disc expanding like logs so that the total cross sections grow like $(\log s)^2$, if $\alpha(0)>\alpha_c$. For $\alpha(0)<\alpha_c$ the total cross sections drop as the universe powers of s.

In the paper by Matinyan et al.[26] the Regge-pole singularities associated with the multiparticle states in t-channel are studied and their role in solving the Mandelstam's program of the linear Regge trajectories is discussed.

III.REGGE/QUARK ANALYSIS

I. Regge behaviour vrs.SU_3/quark structure

Merger of the idea of the Regge(power-like) behaviour with the quark constituent theory,dual model and internal symmetries gives an effective tool for analysis of experimental data.

In the last years a considerable attention has been attracted to the study of the energy dependence of hadron scattering versus SU_3/quark structure of the scattering amplitudes.

Differents authors give various results for the dominant power term $s^{\alpha_p(0)}$ (which might be the case either $\alpha_p(0)=I$ or $\alpha_p(0)>I$ or even $\alpha_p(0)<I$) as well as for the SU_3 structure of the Pomeron couplings (different mixtures of the singlet and octet components).

The reason for such wide variations of possible values of the leading singularity position can be illustrated by Fig.5 from the paper [27].

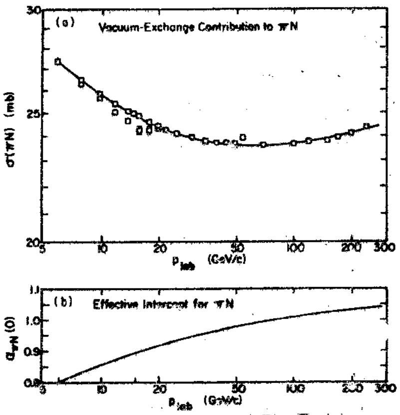


Fig.5(a). The vacuum-exchange contribution to πN total cross sections $\frac{1}{2}(\sigma_t(\pi^+p) + \sigma_t(\pi^-p))$

$\alpha_{\pi N}(0) > I$ at $P_{lab} > 70$ GeV/c .

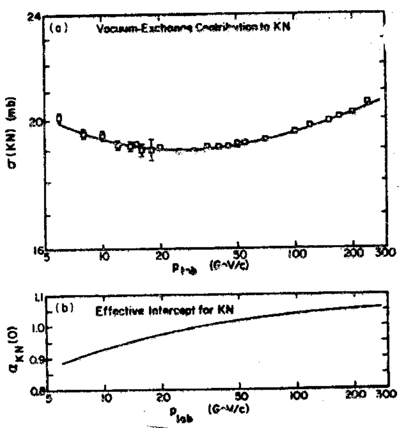


Fig.5(b). The vacuum-exchange contribution to KN total cross sections $\frac{1}{4}[\sigma_t(K^+p)+\sigma_t(K^+n)+\sigma_t(K^-p)+\sigma_t(K^-n)]$

$\alpha_{KN}(0) > I$ at $P_{lab} > 30$ GeV/c .

An effective power of energy dependence is determined by

$$\alpha_{eff}(P_{lab}) = \frac{\partial}{\partial \log P_{lab}}[\mathrm{Im}\, T(P_{lab},t=0)]$$

which gives different values of $\alpha_p(0)$ for various energy intervals. This is in the qualitative accordance with DAR which relates the effective exponent α_{eff} to the ratio of the imaginary-to-real parts of scattering amplitude, i.e.

$$\alpha_{eff} \approx I + \frac{2}{\pi}\rho(P_{lab},t=0), \qquad \text{(DAR)}$$

So, α_{eff} exceeds unity where ρ is negative. The detailed analysis shows the dependence of a spectrum of Regge singularities with the vacuum quantum numbers on the assumed SU_3 or quark structure of hadron scattering amplitude.

2. SU_3- structure of the vacuum exchange

One usually describes the vacuum exchange amplitude as the sum of the Pomeron(diffraction) part and the f-pole(resonance-like or dual) part

$$V.E. = s^{\alpha_p}\hat{p} + s^{\alpha_f}\cdot\hat{f}$$

The SU_3 assignment is determined in the TABLE

		SU_3 - content	
		I	8
Regge terms	p	p_I	p_8
	f	f_I	f_8

Different possibilities for the SU_3-structure and the spectrum of Regge singularities in the vacuum exchange amplitude were considered [27-33]:

* Harari & Freund - P + R(f,f');
* Carlitz,Green,Zee (197I) - P coupled trough f,f' $\alpha_p(0) = I$;
* Bali,Dash(1974) Chew, Rosenzweig (1975) $p=f_0$, f'; $\alpha_p(0) \approx 0.85$
* Lipkin (1974) (p_I,p_2) + R, $\alpha_{p_1} \approx I.13$: $\alpha_{p_2} \approx 0.8$
* Quigg,Rabinovici (1975) $p(\hat{I}+\hat{8}) + f_0$(ideally mixed) $\alpha_p \approx I.075$
* Others.

No unique solution exists!

We mention here general trend, however. The SU_3 structure of the vacuum exchange depends on the transferred momentum (the Pomeron as a "chameleonic" object[3I]).

For t-large and positive, p ideally mixed Regge pole: associated with planar diagrams (in terms of Veneziano's topological expansion[34]). The notion of asymptotic planarity[35] arises related closely to the problem of OZI-rule[36] (Freund, Nambu, I975[37]).

For t-negative and large enough ($-t \geq 0.5$GeV/c^2) p is dominated by SU_3-singlet. This can be illustrated by Fig.6 from ref.[27], where the singlet (s) and octet(0) components of the non-forward scattering amplitudes for the πp- and Kp-systems are determined by

$$\frac{d\sigma}{dt}(\pi p) \approx |s+2O|^2 \approx |s|^2 + 4\mathrm{Re}(s^*O),$$

$$\frac{d\sigma}{dt}(Kp) \approx |s-O|^2 \approx |s|^2 - 2\mathrm{Re}(s^*O).$$

An interesting question arises: at how large t will p be dominated by SU_4-singlet term(if any)? A simple estimation gives the comparatively low value:

$$-t_{cr} \sim \ln \frac{\sigma^2_{tot}(pp)}{\sigma^2_{tot}(p\psi)} \Big/ (b_{pp} - b_{p\psi}) \sim 1 \text{ GeV/c}^2 !$$

Fig.6 (a)(b) The singlet- octet contributions to $d\sigma/dt$

(a) SU_3 - singlet part of vacuum exchange

(b) $Re(S^*O)/|s|$ octet part

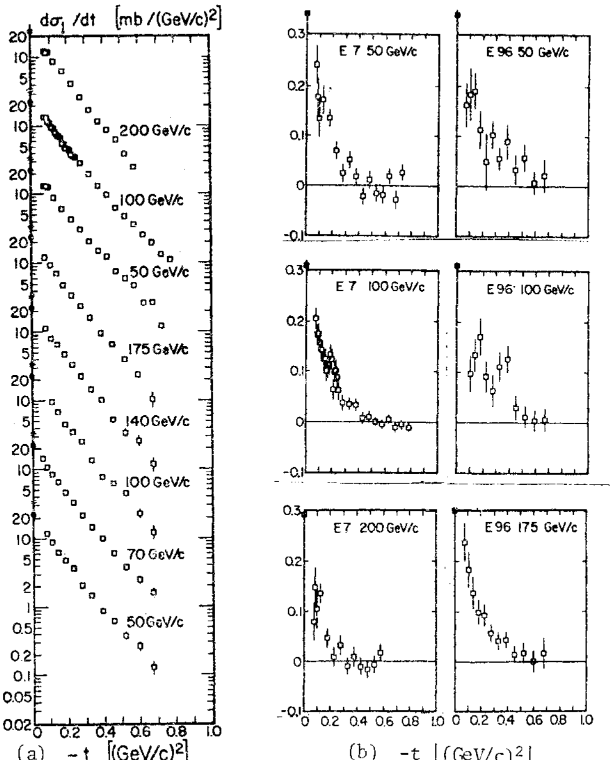


Fig. 6

3. Quark analysis of total cross sections

During the years the quark model was very successful in analysis of regularities in the asymptotic values and variations of the hadron scattering total cross sections. It is now time to ask the following questions:

* Why do some combinations of total cross sections grow, some not?

* Why $\sigma_{tot}(K^+p)$, $\sigma_{tot}(pp)$ and $\sigma_{tot}(\phi p) = 2\sigma_{tot}(Kp) - \sigma_{tot}(\pi p)$, all being pure Pomeronic in two-component duality, have different energy behaviour?

* Why does the Levin-Frankfurt rule [38] $\sigma_{\pi N}/\sigma_{NN} = 2/3$ work only with 10% accuracy and $(\sigma_{\pi N} - \sigma_{KN})$ decreases too slowly?

By the way, it has been noticed in 1971 by Prokoshkin and analysed in details by Denisov et al. [39] on the basis of the Serpukhov experimental data that the ratio

$$R = \frac{2\sigma_{\pi N}}{\sigma_{KN} + \frac{2}{3}\sigma_{NN}} = 1.020 \pm 0.015 \qquad (p_{lab} = 20 \div 60)$$

is consistent with the quark model predictions with much more accuracy than the others.

One of the possible answers to these questions was given by Lipkin who has proposed the three-component picture for the high energy hadron scattering (the first two components for the vaccum exchange, and the third one- for the Regge-pole contribution[40]).

It was assumed that the second vacuum component contributes to πN, KN and NN forward scattering as respectively $2:1:9/2$. Thus, the following sum rule is satisfied:

$$\sigma_{\pi N} = \tfrac{1}{2}\sigma_{KN} + \tfrac{1}{3}\sigma_{NN} \qquad \text{or } R = 1.$$

The model can be formulated in terms of the specific total cross sections $Y_a = \sigma_a / n_a$ (per single quark of a projectile for nucleon as a target:

$$Y = \alpha + \beta \cdot n_{\text{non-strange quarks}}$$

Two terms in this expression belong to the first (p_1) and second (p_2) components of the vacuum exchange. In these terms the famous ratio R=1 corresponds to the equidistance rule $Y_\pi - Y_K = Y_N - Y_\pi$. Notice that while the differences $Y_\pi - Y_K$ and $Y_N - Y_\pi$ pick out the second p_2-component, the differences $Y_\phi = 2Y_K - Y_\pi$ and $Y_\phi' = Y_\pi + Y_K - Y_N$ separate the first p_1 - component with an energy dependence different from that of the previous one: p_1 is slowly increasing ($\sigma \sim s^{0.07}$ or powers of log's); p_2 is slowly decreasing ($\sigma \sim s^{-0.2}$).

A number of interesting generalizations was proposed in [41-42]. The simplest is given by $Y = \alpha + \beta n_{\text{non-strange}} + \gamma n_{str.}$ which leads to the relations between total cross sections of baryons and hyperons:

$$Y_\pi - Y_K = Y_K - Y_\phi = Y_N - Y_{\Lambda/\Sigma} = Y_{\Lambda/\Sigma} - Y_\Xi, \text{etc.}$$

In the paper by Joynson and Nicolescu [41] submitted to the Conference, the new interesting relation between total cross sections is proposed

$$2\sigma_{\pi^+p} - \sigma_{\pi^-p} = \frac{7}{16}\sigma_{K^+p} + \frac{3}{8}\sigma_{pp},$$

which is in a surprising agreement with experimental data (see Fig.7). The authors interpret this by introducing the special form of the second vacuum component for the total cross sections

$$\sigma_{p_2} \sim \frac{1}{n_a n_b} \sum_{i \in a, b} y_i^2;$$

where y_i are hypercharges of quarks in the colliding hadrons a and b.

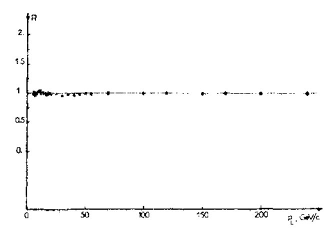


Fig.7. Test of the Joynson - Nicolescu sum-rule. The quantity plotted is $R = (2\sigma_{\pi^+p} - \sigma_{\pi^-p})/(\frac{7}{16}\sigma_{K^+p} + \frac{3}{8}\sigma_{pp})$.

IV. HIGH ENERGY SCATTERING IN MODELS OF QFT. QED & QCD.

I. QED.

Investigation of the high energy asymptotic behaviour in different models of QFT has a long history. Most of these studies are based on the order-by-order calculations as well as on the non-perturbative methods like path-integral methods which were devoted to the problems of leading singularities and the eikonal approximation.

As was shown by Gribov, Frolov and Lipatov and by Cheng and Wu in 1969 in the framework of the massive QED, the main singularity in J-plane is not pole but a fixed branch point above unity, i.e.[43]

$$T \sim s^{1+g^2 C}, \quad s \sim \infty$$

where $C > 0$ is the main logarithm approximation and different for the scalar and vector variants of QED. The evident contradiction with the Froissart theorem is interpreted as being due to the non-reggeization of the massive photon.

In a series of recent papers [44] by Cheng and Wu, the asymptotic behaviour of the fermion-exchange processes and the related question of the fermion reggeization are studied in the framework of QED up to the record of I2-th order in coupling constant.[45]

There are few new results on the eikonal approximation in the models of field theory.[46-49] The asymptotics of "twisted" graphs (obtained by an interchange of two nucleons in the ladder-type graphs being usually studied in works on the eikonal problem) have been found. This gave rise to an effect of a linkage of large nucleon momenta to the mesons, on the one hand, and to the violation of the simple eikonal formula with Yukawa-type interaction potential-on the other.[46] The corresponding corrections to an effective high energy potential were calculated which have more singular behaviour in origin that the Yukawa term, e.g. $\sim \log r/r_0$. The relativistic eikonal representation for the scattering on composite particles was studied in papers [48] by means of the path-integration method.

2. QCD (quantum chromodynamics)

Study of the high energy scattering in non-abelian gauge theories like QCD has recently attracted a great interest.[50] In a number of papers [5I-64] the following problems were attacked:

* What is the leading singularity in J-plane?
* Whether the gauge bosons reggeizes?
* Does the large angle elementary fermion scattering pass the point-like scaling?
* Whether there is a sign of the quark confinement in the high energy scattering amplitudes?

The last question is closely related to the whole problem of the infrared mechanism ("infrared slavery") for quark confinement in QCD which was studued in paper [64]. It was shown by means of the order by order calculations that there is no quark confinement, and the Kinoshita-Lee-Nauenberg theorem[65] is true in the perturbation theory for both the QED and QCD.

The result of the non-perturbative analysis developed in papers [6I-62] on the basis of some renormalization group equations still preserve the general belief in quark confinement in the QCD. The most of results on the high energy scattering in the QCD are made by the order by order calculations up to 6-th (or up to the 8-th order [54]) in coupling constant. The spontaneous breakdown of the gauge group is introduced by the Higgs mechanism [66] into the 't-Hooft's gauge[68] (by the Faddeev's and Popov's receipt [67]) to avoid the infrared problems.

All the necessary elements of Feynman rules to calculate the high energy asymptotic graphs are listed below:

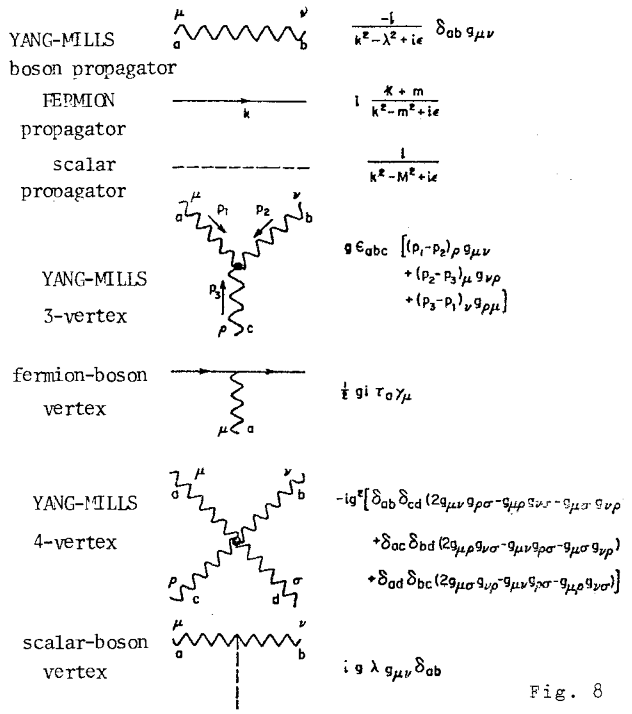


Fig. 8

These include the dimensional coupling of the Higgs scalar with the gauge bosons which goes to zero together with the mass of the vector boson λ (when the symmetry breaking switches off). The results of the calculations for the non-spin - flip amplitudes of the (ff), (fb) and (bb) processes up to the 8-th order can be summarized in the following way:

$$T(\text{non-spin-flip}) = \sum_{i=0,I,\dots} T_i \, \Pi^{(i)} c_i$$

Here, T_i are the universal amplitudes with the t-channel isospin "i"; c_i are some normalization factors depending on channels, and $\Pi^{(i)}$ are the (color) isospin projection operators.

$$T_1 = I - g^2(\xi - \frac{i\pi}{2})f_1 + \frac{g^4}{2!}(\xi^2 - i\pi\xi)f_1^2 - \frac{g^6}{3!}(\xi^3 - \frac{3\pi i}{2}\xi^2)f_1^3 + \ldots$$

that coincides with the decomposition in the leading log's approximation of the cross-odd Regge term.

$$s^{\alpha-1}(\frac{I - e^{-i\pi\alpha}}{2}), \quad \text{where } \alpha = I - g^2 f,$$

$$f_1 = (\Delta^2+\lambda^2)D = (\Delta^2+\lambda^2)\cdot\int \frac{d^2k_\perp}{(2\pi)^3} \frac{I}{(k_\perp^2+\lambda^2)[(k_\perp-\Delta)^2+\lambda^2]},$$

$$T_0 = \frac{a}{\Delta^2+\frac{5}{4}\lambda^2} + (-\frac{a^2}{\Delta^2+\frac{5}{4}\lambda^2} + 4T)\,g^2\xi + (\frac{a^3}{\Delta^2+\frac{5}{4}\lambda^2} - 8aT + 4Q)g^4\frac{\xi^2}{2!} + \ldots$$

where $a = (2\Delta^2 + \frac{5}{2}\lambda^2)D$

$$T = \int \frac{d^2k_{1\perp}}{(2\pi)^3} \frac{d^2k_{2\perp}}{(2\pi)^3} \frac{I}{(k_{1\perp}^2+\lambda^2)(k_{2\perp}^2+\lambda^2)[(k_{1\perp}+k_{2\perp}-\Delta)^2+\lambda^2]}$$

$$Q = \int \frac{d^2k_{1\perp}}{(2\pi)^3} \frac{d^2k_{2\perp}}{(2\pi)^3} \frac{d^2k_{3\perp}}{(2\pi)^3} \frac{I}{(k_{1\perp}^2+\lambda^2)(k_{2\perp}^2+\lambda^2)(k_{3\perp}^2+\lambda^2)} \times$$

$$\times \left\{ \frac{}{(k_{1\perp}+k_{2\perp}+k_{3\perp}-\Delta)^2+\lambda^2} + \frac{(q_{1\perp}+q_{3\perp})^2+\lambda^2}{[(k_{1\perp}+k_{2\perp}+k_{3\perp})^2+\lambda^2][(k_{1\perp}+k_{3\perp}+\Delta)^2+\lambda^2]} \right\}$$

This formula coincides with the decomposition of the expression

$$2s^{-a}(D + 2g^2\xi T + 2g^4\xi^2 Q + \ldots)$$

$$T_2 = \frac{b}{\Delta^2+2\lambda^2} + (\frac{b^2}{\Delta^2+2\lambda^2} - 4T)g^2\xi + (\frac{b^3}{\Delta^2+2\lambda^2} - 8bT + 8Q)\,g^4\frac{\xi^2}{2!} + \ldots$$

Here, $b = (\Delta^2+2\lambda^2)D$

Summing up the first terms in each perturbation order one gets s^b in violation of unitarity (no reggeization).

In terms of the reggeization properties the results consist of the following:

(color)- isospin in the t-channel	Reggeization
$I_t = I$	Yes
$I_t = 0$	?
$I_t = 2$	No

The problem of reggeization is not completely clear for the case of $I_t = 0$, because the following normalization factors found in the paper 54/

ff: $c_1 = -\frac{g^2}{4m^2}\frac{s}{\Delta^2+\lambda^2}$; $c_0 = 2^{-5}\frac{g^4}{m^2}\,3\pi is$;

fb: $c_1 = -\frac{g^2}{m}\frac{s}{\Delta^2+\lambda^2}$; $c_0 = 2^{-2}\frac{g^4}{m}\,i\pi\sqrt{6s}$;

bb: $c_1 = -4g^2\frac{s}{\Delta^2+\lambda^2}$; $c_0 = g^4\,4\pi is$; $c_2 = g^4\,i\pi s$;

satisfy the factorization condition

$c(ff)\cdot c(bb) = c^2(fb)$

for the channel $I_t=0$ as well as well as for the channel $I_t = I$. However, as it has been found in the paper 55/,the leading singularity which belong to $I_t=0$ turns out to be a square root branch point at $J = I + \frac{g^2}{\pi^2}\,2\ln 2$ (for SU_2- gauge group) and results from two reggeized vector exchange.

This indicates to a violation of the Froissart bound in the main logarithmic approximation in QCD as well as in QED.

Thus, the situation is puzzling.Before answering these questions let us make up the balance:

I. There is a place for the reggeization of basic particles;
2. The "superconvergence" of integrals over the transverse momenta is observed; so, the automatic transverse cutoff in $P_\perp$ appears, and one can think the QCD is a candidate for the theory of strong interactions;
3. The results under study correspond to a nonphysical world with the free (non-confined) quarks, antiquarks and gluons.

It seems that all found indications to a quark confinement are illusive,and the whole problem of high energy behaviour in hadronic phase of QCD is still unclear.

In conclusion we shall mention the paper 59/ in which some regularities in behaviour of the hadron multiplicities are considered in the framework of QCD. The increase of the hadron multiplycity in the high energy reactions is attributed here to the necessity of confining the quark quantum numbers("color neutralization").

V. CONSTITUENT THEORY OF THE HADRON INTERACTIONS

I. Dynamical equations in QFT

The constituent picture of the high energy hadron interactions leads to the predictive and consistent theory when combined with a dynamical equation approach in QFT.

The relativistic quasipotential approach was successful in studying the high energy hadron scattering at small and large angles,the form factors of composite particles and many other problems.

There is a number of new results in this direction:

First, I shall mention the density matrix method to describe the multiparticle production processes (see Logunov et al. 70/) which we shall discuss in the following chapter.

Second, there is a development of the null-plane description of composite particles in the framework of the "one-time" quasipotential approach (Tavkhelidze et al.[73]).

In a number of papers[74] the great efforts are made to obtain as much as possible rigorous results on the properties of the n-particle Green functions projected on the null-plane. The spectral and explicit properties of the "two-time" Green functions projected on the null plane are proved. Some of these results were previously found only in the lowest order of the perturbation theory [71-72].

In the paper by Kvinikhidze, Sissakian, Slepchenko and Tavkhelidze [75] submitted to the Conference, the null-plane approach was used in order to obtain a number of general integral representations for the inclusive cross sections which are very useful in the dynamical description of multiparticle production. These results provide the field theoretical grounds for the parton-quark model or constituent- interchange model used by Blanckenbeckler, Brodsky and Gunion to describe the large $P_\perp$ processes[76].

In the paper by Atakishiev, Mir-Kasimov and Nagiev [77] the relativistic Hamiltonian theory with an auxiliary massless spurion field is developed that allows one to exclude all ultraviolet singularities of QFT on the null plane.

The cross-symmetric Bethe-Salpeter equations are studied in the paper by Yaes[78].

2. The Density Matrix Method

The new development of the dynamical approach is made in the paper by Arkhipov, Logunov, Savrin[70] submitted to the Conference, where the method of the density matrix is proposed to describe the multiparticle production processes at high energies

The density matrix of a system of two outcoming nucleons + one additional meson (as an example) is represented by

$$\rho^{(2)}_{\vec{c}}(2,I/2',I') \sim \sum_{\text{others}} T_{2\to 2'+I'+\text{others}}\, T^*_{2\to 2'+I'+\text{others}}$$

as is illustrated in Fig.9:

Fig. 9

Quantum statistical ensemble

The total space momentum of all three particles $\vec{c} = \vec{2} + \vec{I} = \vec{2}' + \vec{I}'$ is fixed in the relativistic invariant one-time description.

The following dynamical equation is true on the general grounds of QFT:

$$(E_k - E)\rho^{(2)}_{\vec{c}}(t) - \rho^{(2)}_{\vec{c}}(t)\,(E_{k'} - E') = V_{\vec{c}}\,\rho^{(2)}_{\vec{c}}(t) - \rho^{(2)}_{\vec{c}}(t)\,V^{+}_{\vec{c}}.$$

Here, $V_{\vec{c}}$ is the integral operator of an effective quasipotential for the three-particle system (2+I or 2'+I') affected by screening of the rest part of multiparticle systems:

$$E_k = (m^2 + \vec{p}^{\,2})^{\frac{1}{2}} + (\mu^2 + \vec{k}^2)^{\frac{1}{2}} + |(\vec{c} - \vec{p} - \vec{k})^2 + m^2|^{\frac{1}{2}}$$

The two-particle correlation function is given by

$$\rho^{(2)}(t) = \int d\vec{c}\,\rho^{(2)}_{\vec{c}}(t),$$

and the one-particle distribution function by

$$\rho^{(1)}(t) = \int \rho^{(2)}_{\vec{c}}(t)\, d\vec{c}\, d\vec{p}.$$

The observable inclusive cross section is determined by the adiabatic limit

$$\lim_{\substack{t\to\infty\\ E=E'}} \rho^{(1)}(\vec{k}, \vec{k}/t) = \delta^3(0)\frac{I}{(2\pi)^2}\frac{d\sigma}{d\vec{k}}$$

where $I = 4\sqrt{(q_1 q_2)^2 - m^2}$ is the initial flux factor.

The authors look for solutions of the eq. for the $\rho^{(2)}$ of the following form

$$\rho^{(2)}_{\vec{c}}(2,I/2',I') \sim \psi_{\vec{c}}(2,I)\cdot\psi_{\vec{c}}(2',I')$$

as the pure three-particle state density matrix. Thus the $\psi_{\vec{c}}(t)$ obeys the quasipotential eq. for the (pseudo) three-particle system

$$(E_k - E)\,\psi_{\vec{c}}(t) = V_{\vec{c}}\,\psi_{\vec{c}}(t)$$

where $V_{\vec{c}}$ takes into account the interaction among three particles screened by other particles in the final states of an inclusive reaction.

$$\frac{d\sigma}{d\vec{k}}(I) \sim \int d\vec{c}\; d2\,|\psi_{\vec{c}}(2,I)|^2$$

The authors have derived the automodel solutions which possess the scaling properties predicted in the Feynman parton model.

Thus, the density matrix method gives a dynamical basis for consistent description of multiparticle reactions in the framework of the constituent models (like Chou-Yang or Van Hove & Pokorski models).

The similar dynamical approach to a multiparticle production has been recently formulated by P.Carruthers and F.Zachariasen[79]. They have shown that the field theoretical description of multiparticle production processes can be cast in a form analogous to the ordinary transport theory where the inclusive differential cross sections are given by integrals of the covariant phase - shift distributions.

VI. POWER LAWS

I. Dimensional Quark Counting for Large Angle Scattering.

Power-like asymptotic behaviour of the large scattering processes and hadron form factors was interpreted in papers[70-72] in terms of the Dimensional Quark Counting (DQC).

As was shown in paper [70], DQC is based on the following general assumptions:

I. Quark structure of hadrons with the confinement.

2. Scale invariance (automodelity) of quark interactions at small distances.

3. Finitness of the quark local densities within hadrons.

In papers[8I-83] DQC is derived from a perturbation theory analysis of the renormalized field theoretical models with quarks and gluons as fundamental fields and hadrons as bound states of quarks.

The DQC leads to the following well-known results:

$$F_a(t) \sim \left(\frac{I}{t}\right)^{n_a-I};\quad \frac{d\sigma}{dt}(ab\to cd) \sim \left(\frac{I}{s}\right)^{n_a+n_b+n_c+n_d-2}\cdot f_{ab\to cd}(z)$$
$$(z=\cos\theta)$$

where n_a is the minimal number of basic point-like constituents (valent quarks, leptons, etc.).

If one chooses $n_{meson}=2$, $n_{baryon}=3$, $n_{lepton}=I$, he can get

$$F_\pi \sim \frac{I}{t}(\text{monopole});\ F_p \sim \frac{I}{t^2}\ (\text{dipole});\ F_e \sim I\ (\text{point-like})\ \text{etc.}$$

and

$$\frac{d\sigma}{dt}(pp\to pp) \sim \frac{d\sigma}{dt}(p\bar{p}\to p\bar{p}) \sim s^{-10},$$
$$\frac{d\sigma}{dt}(\pi p\to \pi p) \sim \frac{d\sigma}{dt}(Kp\to Kp) \sim s^{-8},$$
$$\frac{d\sigma}{dt}(\pi\pi\to\pi\pi) \sim \frac{d\sigma}{dt}(ep\to ep) \sim s^{-6}\ ,\ \text{etc.}$$

This hierarchy of powers is in a qualitative accordance with observation[83].

In addition to the problem of power-like automodel asymptotics in QFT and justification of DQC the following questions still remain:

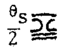
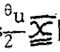
* Angular dependence of $d\sigma/dt$;
* Hadron polarization in large angle processes;
* Absolute scales of $d\sigma/dt$, F(t).

The problem of angular dependence of the large angle scattering cross sections was considered in recent papers [84-92].

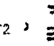
In paper[84] the generalized DQC has been proposed based on a specific dynamical interpretation of quark diagrams describing the quark rearrangement processes at small distances. The generalized DQC states that an asymptotic contribution to the large angle scattering amplitude is determined by the topology of quark diagram as a homogenious function of the large kinematic variables s, t and u.

The analysis of angular dependence of a number of large binary reactions in terms of the helicity amplitudes, under an additional assumption of the γ_5- invariance was performed in [93].

For the meson-baryon scattering it gives, e.g., the general result which can be written in the following symbolic form:

$$\frac{d\sigma}{dt} \sim \frac{I}{s^2}|f_{tt}|^2 \sim \frac{I}{s^2}\left|\cos\frac{\theta_s}{2}\right.$$  $$+\ \cos\frac{\theta_u}{2}$$  $$\Big|^2$$

where θ_s, θ_u are the scattering angles in the s- and u-channels, respectively, and the asymptotics of two quark diagrams are

 $\sim \frac{I}{st^2}$,  $\sim \frac{I}{ut^2}$

The Table of results is given below.

TABLE: Angular dependence of the large angle binary reactions.

Reaction	$d\sigma/dt \sim \left(\frac{I}{s}\right)^{2(n_a+n_b-I)}\cdot f(\cos\theta = z)$
$\pi^+p \to \pi^+p$	$s^{-8}\frac{(I+z)}{(I-z)^4}\left|\beta + \frac{4\alpha}{(I+z)^2}\right|^2$
$\pi^-p \to \pi^-p$	$s^{-8}\frac{(I+z)}{(I-z)^4}\left|\alpha + \frac{4\beta}{(I+z)^2}\right|^2$
$\pi^-p \to \pi^on$	$s^{-8}\frac{(I+z)}{(I-z)^4}\left|\frac{\alpha+\beta}{\sqrt{2}}\right|^2\left(I + \frac{4}{(I+z)^2}\right)^2$
$K^+p \to K^+p$	$s^{-8}\cdot I6\,\frac{(I+z)}{(I-z^2)^4}$
$K^-p \to K^-p$	$s^{-8}\frac{(I+z)}{(I-z)^4}$
$p\bar{p} \to \pi^+\pi^-$	$s^{-8}\,\frac{1}{2}\,\frac{(I+z)}{(I-z)^3}\left|\alpha + \beta\left(\frac{I-z}{I+z}\right)^2\right|^2$
$p\bar{p} \to \pi^o\pi^o$	$s^{-8}\,\frac{1}{2}\,\frac{(I+z)}{(I-z)^3}\left|\frac{\alpha-\beta}{\sqrt{2}}\right|^2\left(I+\left(\frac{I-z}{I+z}\right)^2\right)^2$
$p\bar{p} \to K^+K^-$	$s^{-8}\,\frac{1}{2}\,\frac{(I+z)}{(I-z)^3}$
$pp \to pp$	$s^{-10}(I-z^2)^{-6}\{[(\alpha(I+z)^2+\beta(I-z)^2)^2 + (z\to -z)] + [\frac{2}{I+z}(\bar{\alpha}(I+z)^2 + \bar{\beta}(I-z)^2)^2 + (z\to -z)]\}$.
$p\bar{p} \to p\bar{p}$	$s^{-10}\frac{(I-z)^{-6}}{64}\{[4\bar{\alpha} + \bar{\beta}(I-z)^2)^2 + +(4\bar{\beta} + \bar{\alpha}(I-z)^2)^2 + [\frac{(I+z)}{2}(4\alpha + \beta(I-z)^2) - \frac{I+z}{I-z}(4\beta + \alpha(I-z)^2)]^2\}$

On the basis of these formulas as well as on the basis of the quasipotential equation with the analytic interaction potentials a new analysis of experimental data has been performed by Kuleshov, Goloskokov, Smondyrev et al. in the paper submitted to the Conference [92] (see Figs.10,11). The authors have shown that

1. $V \approx A$, or the vector-vector and axial-axial vector couplings in $pp/p\bar{p}$ scattering approximately coincide.

So, only same/opposite helicities couple in the proton/antiproton scattering on the nucleon.

2. The double-quark pair exchange is suppressed by two orders of magnitude as compare with a single-quark model.

This analysis shows that the study of angular dependence can give a rich and important information on the dynamics of large angle scattering and quark processes going at short distances.

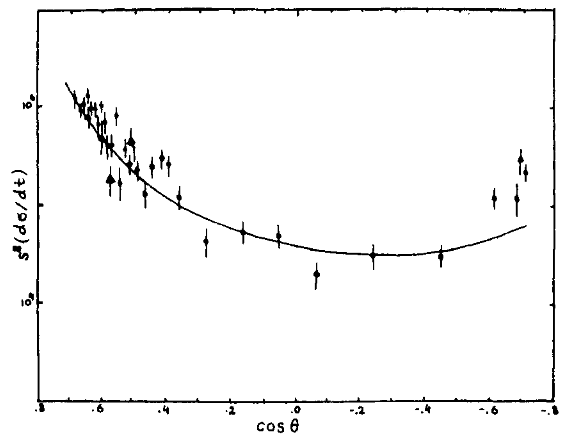


Fig.10. $s^8 \frac{d\sigma}{dt}$ for $\pi^+ p$ scattering.

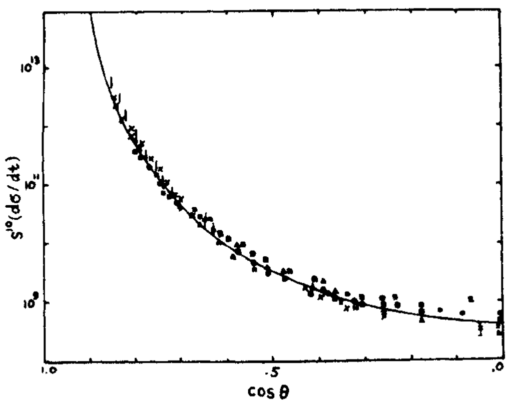


Fig.11. $s^{10} \frac{d\sigma}{dt}$ for pp scattering.

2. Asymptotics of nuclear form factors and structure function.

The dimensional quark counting gives a very simple and direct relationship between asymptotic form of the hadron form factors and complexity of hadrons.

There is an interesting question whether this relationship can be brought into the nuclear physics where fortunately one deals with objects whose complexity varies in wide limits. This question as well as the whole problem of the quark degrees of freedom for nuclei was apparently first arised by A.M.Baldin [94] and discussed in a number of recent papers.

An analysis of recent experimental data on the deuteron electromagnetic form factor as well as the new results of measurements of e^-D elastic and inelastic scattering from $q^2=0.8$ up to 6.0 GeV^2 were presented by Arnold et al. [97]. An evidence on the absence of the meson exchange currents is found in these experiments accordingly to the quark picture of the processes.

The test of the dimensional quark counting predictions for the form factors of hadrons and a deuteron can be illustrated in Figs.12,13 from the paper by Brodsky and Chertok [98].

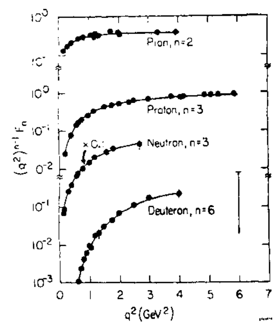


Fig.12. Test of the Dimensional Quark Counting predictions with the experimental data for the pion (electroproduction data) proton /neutron and elastic deuteron form factors.

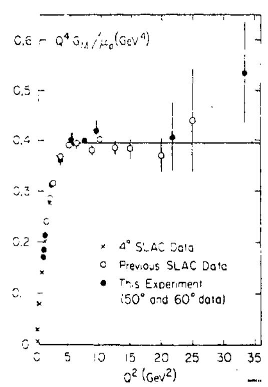


Fig.13. Comparison of the Dimensional Counting prediction with the SLAC experimental data.

One of the most important problems which have to be understood is the value of the level of "flattening out" of the deuteron form factors.

It seems that this is connected to the relative time which the deuteron spends as a six-quark system (not as a losely bound two-nucleon system). To answer such a question one needs a more sophisticated theory of a nucleus in terms of quark degrees of freedom (like quark bag model of nucleus).

VII SCALING AND SIMILARITY LAWS

I. Automodelity in Strong Interactions

Study of the scaling and similarity properties of strong interactions at high energies is interesting from two points of view. First, it is a question of structure of elementary particles and of interaction dynamics at short distances; second, it is a search for a new energy scale (or fundamental length) which could change (if exists) considerably the picture of strong interactions at superhigh energies.

A great number of papers has appeared as a result of an observation of scaling effects in spectra of secondary particles in the experiments carried out at the Serpukhov accelerator and following the Feynman formulation of scaling phenomena in terms of the quark-parton model[I00/]. Many interesting experimental and theoretical results were obtained in that direction.

In papers[I0I/] a general approach to the description of scaling and similarity properties has been developed based on the idea of the automodelity.

The term "automodelity", (or "selfsimilarity") itself, belongs to the theory of the gazo-and hydrodynamic phenomena. An analogy of these phenomena to the scaling properties of deep-inelatic processes has been noticed by N.N.Bogolubov in I969. It is worth to be mentioned, particularly, in connection to the physics of deep-inelastic lepton-hadron scattering, where the character of scaling laws indicates to the analogy with the so-called "point-like explosion" in gazo/hydrodynamics. The scaling regularities in the processes of strong interactions of hadrons at high energies lead to an analogy with the "plane-like" explosion. We emphasize, however, that the analogy with the "plane-like" explosion corresponds only to the processes with bounded momentum transfers, the dynamics of which is determined by the finitness of effective interaction radius of strong interactions [99/]. In these processes hadrons look as extended objects with infinitely small longitudinal sizes (due to the Lorentz contaction in a system with infinite momentum, i.e. "$P_z \to \infty$"). This allows one to consider the scaling properties of observable quantities under the transformation (the delatations of the longitudinal scale of momenta) as: $P_z \to \lambda P_z$; $P_\perp \to P_\perp$

A separation of the transverse and longitudinal degrees of freedom in description of the interaction processes at bounded momentum transfers which is specific in this approach, leads to a whole number of scaling laws for the amplitudes and cross sections of inclusive as well as of binary reactions (note results of the Mueller-Kancheli approach and quark-parton model).

The automodelity principle leads, particularly, to the requirement for all the quantities of the type

$$\sigma_{tot},\ \sigma_{el},\ B=(\log\sigma')_{t=0}\ \text{etc.}$$

with the same dimensionalty T^2 (in terms of scale of the transverse length T), to have a weak and universal energy dependence on the same footing. This phenomenon known as the law of geometrical scaling is in good accordance with the existing experimental data.

We have noticed in a number of papers[I03/] that the geometrical scaling laws were effectively mearged with the quark analysis of the hadron interaction total cross sections. It has to be stressed that a weak energy dependence of the transverse length effective scale (say $R^2 \sim \sigma_{tot}$) points to an approximate character of scaling laws related to the similarity transformations,

$$P_\perp \to \lambda P_\perp,\quad P_z \to P_z$$

the separation of the longitudinal and transverse degrees of freedom being suggested for an ideal case.

2. Study of scaling in QFT.

A number of new interesting results was obtained in studying the scaling properties of hadron interactions in the framework of the local QFT. First of all, we shall mention the axiomatic studies of large angle processes which were initiated by the rigorous applications of the Dyson -Lehmann-Jost representation to an investigation of the automodel (scale invariant) asymptotics in the deep inelastic scattering (see Bogolubov, Tavkhelidze and Vladimirov [I04/].

An extension of this approach to the large $P_\perp$ inclusive reactions on the basis of the DJL-representation was made by Logunov, Mestvirishvili et al. in I974[I05/].

The main problems of the axiomatic approach are:

* Consistency of the power-like automodel asymptotics with the general requirements of the local QFT;

** Relations between asymptotic forms in different channels and regions;

*** Connection to the space-time picture of processes.

In the paper by Geyger et al.[106] submitted to the Conference, the results of simultaneous study of three processes (on the basis of the DLJ-representation) are presented:

$p_1 + q_1$ (on shell) $\to p_2 + q_2$ (on shell)

$p_1 + q_1$ (on shell) $\to p_2 + q_2$ (off shell)

$p_1 + q_1$ (off shell) $\to p_2 + q_2$ (off shell)

It is shown that

- on - and off-shell amplitudes can have different asymptotic behaviour at large momenta;
- absorptive and dispersive parts of the amplitudes on-mass shell can have different asymptotics at large angles.

For instance, the automodel (power-like) asymptotics of the process $\gamma(q^2) + p \to \pi/_\rho + p$ could have different character at $q^2=0$ and $q^2 \to -\infty$.

The consistent description of scaling properties in terms of the density matrix method was given in paper[70]. Starting from the dynamical equation for a density matrix of a subsystem of particles in final states of the inelastic multiparticle reaction, under rather general assumption on the character of interaction quasipotential, the authors[107] have derived the radial type scaling for the inclusive cross sections. The result is in good agreement with existing experimental data on the inclusive production at high energies[108].

In the paper mentioned above an interesting application of the DM-method to the deep-inelastic scattering is given.The well known Bjorken scaling is found in the one-photon approximation. In general case (for all orders in the coupling constant) the cross section scales in terms of two dimensionless variables are: $\omega = I - w^2/_{q^2}$ (Bjorken) and $x = I - w^2/_s$ (Feynman). In the intermediate case (multiphoton with the one-photon approximation for the scattering on a single "constituent"),the new scaling has been found with the dimensional variable

$$\zeta = \frac{x(I-x)}{(2-x)(\omega-I)}$$

Moreover, it was shown that the DM-method gives a clarification of the correlation between the elastic and inelastic characteristics of particle interactions, as it can be illustrated by the solution

$$\frac{d\sigma}{d\vec{k}_\perp} = c(E)\int d\vec{b}\sigma(\vec{b})\,\rho(\vec{b},\vec{k}_\perp)$$

which was found and discussed in the papers by Savrin,Semenov,Tyurin,Khrustalev[109] submitted to the Conference. Here, $d\sigma/_{d\vec{k}_\perp}$ is an inclusive cross section of "soft" mesons, and $\sigma(\vec{b})$ is determined by overlapping of the elastic profiles of initial particles

$$\sigma(\vec{b}) = \int d\,\vec{b}'t_{el}(\vec{b}')t^*_{el}(\vec{b}-\vec{b}')$$

and $\rho(\vec{b},\vec{k}_\perp) \sim \int d\,\vec{\Delta} e^{-i\vec{b}\cdot\vec{\Delta}} g(\vec{k}-\vec{\Delta})\times g(\vec{k}+\vec{\Delta})$,

$g(\vec{k}-\vec{\Delta}) = |\phi_{\vec{k}+\vec{\Delta}}(\vec{k})|^2$ is "a distribution of mesonic constituents" within a screened nucleon with a total momentum $\vec{k}+\vec{\Delta}$.

In the paper by D.Crewther and G.C.Joshi[110] submitted to the Confereence, the scaling properties of the dual resonance model with the Mandelstam analyticity were studied. Non-linear trajectories are used when calculating the scaling functions which are in reasonable agreement with the experiments.

Factoization properties of the exclusive and inclusive cross sections were discussed in papers [111].

The detailed discussion of scaling in the inclusive multiparticle production processes is given in a review talk by Chliapnikov.

SEARCH FOR THE FUNDAMENTAL LENGTH

The success of the most scaling and similarity relations depends on the absence of an energy scale which will be essential at available energies.

What do we expect from the very high energies?

In the invited talk given by Kadyshevsky[112] there is an interesting discussion about the existence of the fundamental length l which should be a key to understand the phenomena at very high energies.

This discussion is based on the version of QFT with a fundamental length[113] which is an alternative to the local QFT in the same sense as the non-Euclidean geometry is a unique alternative to the Euclidean one.Some implications of this theory are listed below:

I. Masses of elementary particles are bounded from above,i.e. $m \leq I/_l$;
2. Modification of the usual uncertainty relation between the momentum transfer q and size of interaction r: $r \sim 1/_{\log(lq)}$ instead of $\sim I/_q$;
3. Geometrical interpretation of the power laws such as $d\sigma/_{dt} \sim (l^2 s)^{-\nu} f(t/_s)$;
4. Parity violation at very high energies $E \gtrsim I/_l$ owing to the modification of the fermion propagator $|\not{p} + (I/_l - \sqrt{I/_{l^2} -}$

$l \sim l_{Fermi} \sim I0^{-17}$ cm?

5. Sharp fall of the $\sigma_{tot}(e^+e^- \to \text{hadrons})$ at $s > l^{-2}$ and a slower decrease with $Q^2 < l^{-2}$ of the deep-inelastic e^-p scattering cross sections.

This analysis shows that a search for the fundamental length could be one of the intriguing tasks for super-high energy physics at the accelerators of next generation.

VIII. SOME CONCLUDING REMARKS

I would like to conclude this talk with some remarks. Obviously, the list of interesting questions written below is no way complete and it is based mainly on the author's impressions.

I. Asymptotic energies are not yet reached, e.g. s^α behaviour for the total cross sections with $\alpha > I$ is allowed by experimental data; polarization in pp-scattering is still nonzero,etc. Apparently, these questions are problems to be studied at the accelerators of next generation.

2. Nature of the vacuum exchange (Pomeranchuk singularity) is still an enigma and waits for its explanation.

3. A close relationship between the t-dependent SU_3-structure of the vacuum exchange and the OZI-rule regularities in the heavy meson decays,apparently,exists.This makes deeper the Regge idea on relationship of high energy behaviour and particle properties with the relevant quantum numbers.

4. Experiments with the high energy hyperon beams and study of $\psi/_J$ -hadron interactions should be very desirable to understand the quark regularities in the total cross sections.

5. Situation with the quark confinement in QCD is still puzzling. Its understanding is important for high energy physics on the whole.

6. Measuring of angular dependence, polarizations and phases of scattering amplitudes of the binary reactions at large angles is important to understand how far are really good predictions of the Dimensional Quark Counting.

7. Quark degrees of freedom seem to be important for a description of nucleus interactions at high energies and large transferred momenta.

8. Presence of the fundamental length or new energy scale could change drastically the picture of particle interactions at extremal energies.

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