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THE AMPLITUDE OF THE ELASTIC HADRON-HADRON SCATTERING IN THE COULOMBIC RANGE OF TRANSFER MOMENTA

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The elastic hadron-hadron scattering plays an important role in the investigation of strong interaction. For the description of the interaction at small distances we have the exact theory - QCD, but for the interaction at large distances, which is the basis for the elastic scattering at small angles, the calculation in the framework of QCD is impossible for the present. That is why the experimental definition of the parameters of the elastic scattering is very important for the development of the modern strong interaction theory. Moreover the imaginary part of the amplitude of the elastic scattering is connected with the total cross section

$$\sigma_{tot}(s) = 4\pi \, Im \, T(s, t=0) ,$$

which is the basis characteristic of any theory or model of strong interactions. The differential cross sections measured in the experiment are described by the square of the scattering amplitude

$$d\sigma/dt = \pi \mid T(s,t) \mid^2, \tag{1}$$

which in the range of small angles can be represented in the eikonal form

$$T(s,t) = \iota \int_0^\infty \rho \, J_0(\rho\Delta) \, (1 - \exp(- \chi(s,\rho)) \, d\rho, \tag{2}$$

where the eikonal phase $\chi(s,\rho)$ is defined by the potential of the hadron interaction

$$\chi(s,\rho) = \int^\infty dz \, V(s,\rho,z) \tag{3}$$

The potential of the charge hadron is the sum of coulomb and nuclear interactions. After the eikonal summing the terms with the coulomb and nuclear interactions appear. The diagrams, with intersecting lines giving a sufficiently large contribution/1/, cancel each other/2/. As a result the total interaction amplitude has a complicated structure and depends on the spin parameters. However, at sufficiently high energies and small scattering angles the contribution of the spin exchange amplitudes can be neglected. In the case of gaussian potentials of the hadron interaction the total amplitude can be represented as a sum of coulomb and hadron amplitudes with the correction of the coulomb- hadron phase shift/3/

$$F_{tot} = F_N + F_C \exp(\iota\alpha\varphi). \qquad (4)$$

For the coulomb amplitude we have the ordinary representation:

$$F_c = \mp 2\ \alpha\ G^2/|t|\ ; \qquad (5)$$

α is the fine-structure constant and $G^2(t)$ is the proton electromagnetic form factor squared.

The phase of the coulomb-hadron interaction has been calculated and discussed by many authors /3-6/ and has the form/5/

$$\varphi(s,t) = \mp [\ \gamma + \ln\ (B|t|/2) + \ln\ (1 + 8/(B\Lambda^2)) + + (4|t|/\Lambda^2) * \ln\ (4|t|/\Lambda^2) + 2|t|/\Lambda^2], \qquad (6)$$

here Λ is the constant entering into the dipole form-factor. One should pay attention that the phase depends on the slope of the hadron amplitude, $B(s,t)$, which in its turn depends on the energy scattering s and transfer momentum t. The calculations of the phase are carried out for the case of gaussian potentials; and as the real hadron potential has a more complicated form with the transfer momentum, the phase has to differ from the form (6) too. In analyzing the experimental data the situation becomes somewhat easier due to the fact that the phase $\varphi(s,t)$ changes its sign in the region of the coulomb-hadron interference and therefore, it is small/6/. That is why the use of different forms of the phase leads to nearly the same results. The pure hadron amplitude is represented in the exponential form in the range of the diffraction peak and small interval of t:

$$F_N(s,t) = h * (i + \rho) * \exp(- B(s,t)/2 * |t|), \qquad (7)$$

h is the effective interaction constant and the fact that the hadron amplitude has the real and imaginary parts is represented by the coefficient

$$\rho(s,t) = Re\ F(s,t)\ /\ Im\ F(s,t), \qquad (8)$$

in various models it depends on s and t in a different way and maybe very sharp/7/. In the experiment the coefficient $\rho(s,t)$ is obtained from the analysis of the differential cross sections in the region of the coulomb-hadron interference where the coulomb and hadron amplitudes are nearly equal to one another and their interference term has the maximum relative contribution.

At the present time, it is considered that the basic characteristics of the hadron amplitude are known rather exactly both from experimental and theoretical viewpoints/8/, within the inclusion of the second order diagrams of the electromagnetic interactions. And at $t = 0$ we have

$$B \sim \ln s\ ; \qquad \sigma_{tot} \sim \ln^2 s.$$

Some problems appeared after the experimental measurement of $\rho(s,t)$ at $\sqrt{s} = 540$ GeV giving $\rho(0) = 0.24$ /9/ which is more than the expectable value 0.15. And the recent measurement of σ_{tot} at $\sqrt{s} = 1.8$ TeV gave at first the value 78.3 mb/10/ which confirms the $\ln^2 s$ physics/11/, but later on it changed the value to 72.1 mb/12/, which is near to the $\ln s$ behavior of the total cross sections/13/.

In this work, we carry out a careful analysis of the available experimental data trying to escape any model assumptions. Such an analysis shows that the supposition about the slope of the differential cross sections in the coulomb range being equal to the slope at the transfer momentum, where we can neglect the coulomb interaction, is wrong. As a result, we obtain somewhat different values of the total cross section, slope and ρ. Deriving formula (1) for differential cross sections we have

$$d\sigma/dt = \pi\ (F_c^2(t) + Re\ F_N^2(s,t) + Im\ F_N^2(s,t) \mp 2\ (Re\ F_N * F_c * \cos(\alpha\varphi) + Im\ F_N * F_c * \sin(\alpha\varphi))) \qquad (9)$$

or consequently

$$d\sigma/dt = \pi\ (F_c^2(t) + (1 + \rho^2(s,t)) * Im\ F_N^2(s,t) \mp 2\ (\ \rho(s,t) + \alpha\varphi)) * Im\ F_N * F_c) \qquad (10)$$

Just this formula is used for the fit of experimental data defining the coulomb and hadron amplitudes and the coulomb-hadron phase to obtain the value of $\rho(s,t)$. Solving (10) with respect to the imaginary part of the hadron amplitude

$$Im\ F_N(s,t) = -\frac{(\rho+\alpha\varphi)}{(1+\rho^2)} F_c + \left[\frac{(\rho+\alpha\varphi)^2}{(1+\rho^2)^2} F_c^2 + \right. \tag{11}$$

$$\left. + \frac{1}{(1+\rho)^2}\left(\frac{d\,\sigma(s,t)}{dt}(1 + \alpha^2\varphi^2)\ F_c^2\right]^{1/2}.$$

Here, the one-to-one correspondence of the imaginary part of the hadron amplitude and $\rho(s,t)$ is seen. At each point of transfer momentum, using $\rho(s,t)$ we can obtain $Im\ F_N(s,t)$ from the experimental data of the differential cross sections. However, it is to be noted that some indeterminacy appears because of the presence of the slope parameter in the phase $\varphi(s,t)$. This indeterminacy can be removed by the iteration but only in the whole set of values of $d\sigma/dt_i$ of the experiment at s_j. Assuming that in this interval of t_i. $Im\ F_N(s,t)$ can be reproduced by the exponential form with the slope $B_1(s)$ we can describe the set of the obtained points and determine the value of the slope with the minimization of χ^2. Then, this value of the slope is substituted into the phase $\varphi(s,t)$ and all procedure is repeated. Thus, we obtain the form of the imaginary part of the scattering amplitude with the parameters one-to-one corresponding to formula (11). Note that by this we propose that $\rho(s,t)$ changes slowly in the considered range of transfer momenta. We discuss this question briefly at the end of this paper.

Now let us consider the data of the proton-proton elastic scattering/14/. In the case when we use the parameters obtained or used in this work , the form of the imaginary part of the scattering amplitude is reproduced in fig. 1a. One can see that the value of the slope in the range of very small t differs from its value at larger t. If we divide the interval of the relevant t in two approximately equal parts, then the value of the slope in the range of small t will be more than two times larger than the value in the other part of t. In this case, the value of the slope in this second part will be much larger than the value of the slope used in processing experimental data to obtain the value of ρ, and taken from the range of transfer momenta where we can neglect the contribution of the coulomb force.

One can see a similar picture at other energies (fig. 2) and for another reaction, proton-antiproton elastic scattering/15/ (fig.3), but as if with an opposite sign. Such a sharp change of the behavior of the scattering amplitude is unlikely as one cannot imagine any physical mechanism leading to such a behavior.

It is more reasonable to assume that the values of $h \sim \sigma_{tot}$; ρ; B we used are wrong. We will not suppose beforehand these values but determine them only from fitting the experimental data. If the number of experimental points permits us, we can do the fit for two intervals of t so that the values of the slope in these intervals would be equal. In this way we will obtain new values (tables I, II, III) for the experiments where any values have been fixed. In these tables variant I refers to calculations with the parameters taken from the experimental works; these parameters are shown in them. Variant II is related to the definition of all values from the experimental data, the variant assumes them as free parameters either imposing the condition on the behavior of the slope in two intervals of t ($B_1 = B_2$) or simply minimizing χ^2. Both these cases lead to almost the same results for the values of ρ, B и σ_{tot}.

However, a contradiction appears here for the experiments which used for their normalization the value of σ_{tot} from the extrapolation of the experiments. The case is complicated by that the determination of the values of σ_{tot} in any of the three methods for their measurement we have used the extrapolation of the hadron amplitude in t = 0 GeV^2 assuming the concrete value of the slope. If the value of the slope at very small t differs from B at $|t|$ = 0.1 GeV^2, the value of the σ_{tot} will be different too.

Таблица I

$\sqrt{s}$ GeV	$\lvert t\rvert_{min}$ GeV^2	$\rho = Re\,F_N / Im\,F_N$		
		Вариант I	Вариант II	Вариант III
9.97	6.3 10^{-4}	− 0.153	−0.13	−0.146
12.3	6.6 10^{-4}	− 0.096	− 0.075	− 0.075
19.4	6.6 10^{-4}	− 0.034	− 0.027	− 0.002
22.2	5.0 10^{-4}	− 0.009	0.006	0.006
23.5	3.7 10^{-4}	0.022	0.022	0.022
23.9	6.6 10^{-4}	− 0.011	0.012	0.019
27.4	4.7 10^{-4}	0.012	0.035	0.022
30.6	5.0 10^{-4}	0.042	0.034	0.022
44.7	9.9 10^{-4}	0.062	0.063	0.070
52.8	10.7 10^{-4}	0.077	0.081	0.069
62.3	54.3 10^{-4}	0.095	0.095	0.095

Таблица II

$\sqrt{s}$ GeV	$\lvert t\rvert_{min}$ GeV^2	$\sigma_{tot} \sim h$ (mb)		
		Вариант I	Вариант II	Вариант III
9.97	6.3 10^{-4}	38.3	39.2	39.21
12.3	6.6 10^{-4}	38.31	39.0	39.0
19.4	6.6 10^{-4}	38.97	39.44	39.15
22.2	5.0 10^{-4}	39.3	39.86	39.86
23.5	3.7 10^{-4}	39.65	39.72	39.7
23.9	6.6 10^{-4}	39.57	40.34	40.22
27.4	4.7 10^{-4}	39.6	40.9	41.14
30.6	5.0 10^{-4}	40.16	40.12	40.04
44.7	9.9 10^{-4}	41.7	41.98	41.57
52.8	10.7 10^{-4}	42.38	42.46	42.5
62.3	54.3 10^{-4}	43.55	43.5	43.5

Таблица III

$\sqrt{s}$ GeV	$\lvert t\rvert_{min}$ GeV^2	$B = d/dt\,(ln\,(d\sigma/dt))$ GeV^{-2}		
		Вариант I	Вариант II	Вариант III
9.97	6.3 10^{-4}	10.83	12.4	12.03
12.3	6.6 10^{-4}	11.06	12.33	12.33
19.4	6.6 10^{-4}	11.56	12.87	13.38
22.2	5.0 10^{-4}	11.7	12.95	12.95
23.5	3.7 10^{-4}	11.8	11.93	11.93
23.9	6.6 10^{-4}	11.83	13.7	13.8
27.4	4.7 10^{-4}	11.8	14.15	13.8
30.6	5.0 10^{-4}	12.0	12.04	11.5
44.7	9.9 10^{-4}	12.8	13.53	13.5
52.8	10.7 10^{-4}	12.87	12.86	12.77
62.3	54.3 10^{-4}	13.02	13.11	13.17

Таблица IV

$\sqrt{s}$ GeV	$\lvert t\rvert_{min}$ GeV^2	Вариант I	Вариант II	Вариант III	
		χ^2	χ^2	N	χ^2
9.97	6.3 10^{-4}	48.7	38.	1.015	37.6
12.3	6.6 10^{-4}	27.6	24.1	1.	24.1
19.4	6.6 10^{-4}	44.6	38.5	.97	36.5
22.2	5.0 10^{-4}	36.6	27.9	1.	27.9
23.5	3.7 10^{-4}	12.8	12.5	1.	12.5
23.9	6.6 10^{-4}	44.9	37.7	.99	37.5
27.4	4.7 10^{-4}	36.1	26.75	1.02	26.2
30.6	5.0 10^{-4}	82.21	82.19	1.01	74.2
44.7	9.9 10^{-4}	41.86	23.9	.98	21.4
52.8	10.7 10^{-4}	42.38	39.2	1.01	36.6
62.3	54.3 10^{-4}	14.7	14.7	1.	14.7

Таблица V (AP P – AP P)

$\sqrt{s}$ GeV	$\lvert t\rvert_{min}$ GeV^2	$\rho = Re\, F_N / Im\, F_N$ Вариант I	Вариант II	Вариант III
30.4	6.7 10^{-4}	0.055	0.12	– 0.01
52.6	9.7 10^{-4}	0.106	0.106	0.13
62.3	63.2 10^{-4}	0.104	0.104	0.16
546.	22.5 10^{-4}	0.23	0.23	0.19

Таблица VI (AP P – AP P)

$\sqrt{s}$ GeV	$\lvert t\rvert_{min}$ GeV^2	$\sigma_{tot} \sim h$ (mb) Вариант I	Вариант II	Вариант III
30.4	6.7 10^{-4}	42.13	39.65	40.22
52.6	9.7 10^{-4}	43.32	43.32	43.87
62.3	63.2 10^{-4}	44.12	44.12	42.8
546.	22.5 10^{-4}	60.3	60.23	57.8

Таблица VII (AP P – AP P)

$\sqrt{s}$ GeV	$\lvert t\rvert_{min}$ GeV^2	$B = d/dt\ (ln\ (d\sigma/dt))$ GeV^{-2} Вариант I	Вариант II	Вариант III
30.4	6.7 10^{-4}	12.7	4.1	11.75
52.6	9.7 10^{-4}	13.03	13.05	12.80
62.3	63.2 10^{-4}	13.47	13.47	12.75
546.	22.5 10^{-4}	15.6	15.58	15.76

Таблица VIII (AP P – AP P)

$\sqrt{s}$	$\lvert t\rvert_{min}$	Вариант I	Вариант II	Вариант III	
GeV	GeV^2	χ^2	χ^2	N	χ^2
30.4	6.7 10^{-4}	23.21	14.29	0.9	11.8
52.6	9.7 10^{-4}	9.8	9.78	1.04	8.9
63.3	63.2 10^{-4}	10.3	10.24	0.97	9.97
546.	22.5 10^{-4}	50.7	46.2	0.9	45.88

The importance of the extrapolation contribution is seen from paper/16/ where the contribution to σ_{tot} of the σ_{obs}, the directly measured value, and of $\Delta\sigma_{el}$ and $\Delta\sigma_{in}$, the extrapolating contributions of the elastic and inelastic cross sections, are shown at energies $\sqrt{s}$ = 30.6 GeV, 52.8 GeV и 62.7 GeV. One can see that the growth of the total cross sections is due to $\Delta\sigma_{el}$ by 50% for the proton-proton and nearly by 100% for the proton-antiproton scattering.

Thus, a closed circle arises. For the measurement of one of the values of σ_{tot}, B , ρ we should know the other two, but for their measurements we have to know the first value. Earlier, the assumption of a possible extrapolation of the slope from the range where the coulomb interactions can be neglected to the coulomb range gave the exit from this circle. If this assumption is wrong, and it has some basis, the theoretical indeterminacy appears in the definition of this value.

In order to go out from this circle we propose measurements at very small t which is the essential coulomb range. It permits us to introduce the correction coefficient to the normalization of the differential cross sections on the basis of the knowledge of the coulomb interactions at least with the accuracy ~ α^2. The idea is based on different dependence of the terms of (11) on t.

$$\frac{d\sigma}{dt} \sim \frac{1}{t^2} F_c'^2 + \frac{1}{t}(\rho + \alpha\varphi) F_c' F_N + (1+\rho^2) F_N^2$$

It is clear that if we differentiate with respect to t, the term connected with the pure hadron amplitudes disappears almost completely. The interference term at t ~ 10^{-4}GeV^2 is small in comparison with the coulomb term due to the difference in the degrees t and small values of ρ and $\alpha\varphi$. Thus, if we take the difference of the differential cross sections measured at two points t_1 and t_2 and divide by its theoretical difference, we obtain the correction coefficient to the normalization of the measured differential cross sections

$$k = \frac{\Delta F_c + \Delta(\text{Interf}) + \Delta F_N}{(d\sigma/dt)_{t1} - (d\sigma/dt)_{t2}} . \tag{13}$$

The correct differential cross sections will be

$$d\sigma/dt = k * (d\sigma/dt)_{exp} \tag{14}$$

Thus, the next scheme arises. One sets t_1 and approximately expected values of B, ρ, h. Then, we calculate $F_c(t_1)$, $F_N(t_1)$ and $\varphi(t_1)$, take the experimental data, define the coefficient k and recalculate the experimental data. Then, we calculate the imaginary part of the hadron amplitude and define B, ρ, $h \sim \sigma_{tot}$ using the free fit. Thus, as this procedure of calculating the coefficient k does not depend on h^2 and practically on B and weakly depends on h and ρ, the definition of these parameters is maximally correct from theoretical viewpoint. For more exactness we can use the iterative loop. Thus, we use the obtained values of B, ρ and h for getting the value of the coefficient k and then we repeat all procedure again. The coefficients k thus obtained and the relevant χ^2 are shown in Tables IV and VIII for the experiments considered. It is clear that the introduction of the coefficient k allows one to improve and χ^2. The obtained new values B, ρ and σ_{tot} are represented in variant III, and the new form of the imaginary part of the scattering amplitude is shown in Figs. 1c, 2c and 3c.

The most essential changes arise at smaller energies where the experiment gives the value of the differential cross sections at the smallest transfer momenta. Just at these energies the total cross sections and ρ grow. Certainly, the errors increase with the free fitting of all parameters and on the average they amount to 0.25 mb for the total cross sections. The largest difference from the previous value is for the slope B. Especially it can be seen at the energies $\sqrt{s}$ = 23.5 и 23.9 GeV. For the proton-proton elastic scattering the values of the slope are essentially large which testify to incorrectness of the previously used supposition about the possibility of extrapolation B from the clear hadron range into the coulomb range. In this case, the values of the slope of the proton-antiproton scattering are smaller than the previous ones and are either smaller or equal to the values of the slope of the proton-proton scattering. It is a pity that we haven't more experimental results of the proton-antiproton elastic scattering[17], which have been published only graphically.

The obtained results can be verified by measuring the slope of the proton-neutron elastic scattering. In this case, for the differential cross section we have

$$\frac{d\sigma}{dt} = \frac{\pi \alpha^2}{m_n^2} k_n^2 * \frac{1}{t} + h^2 \exp(-B|t|) . \tag{15}$$

Here k_n^2 is an anomalous magnetic moment of the neutron, and m_n is its mass.

In the work[18], the results of the proton-neutron scattering at the energies from p_L = 100 to 400 GeV. and in the range of transfer momenta $6\ 10^{-6} < |t| < 5\ 10^{-1}$ GeV^2 are given. However, the data of the differential cross sections with the energy interval 100 GeV start with $-t = 1.1\ 10^{-3}$ GeV^2, and for all energy interval from 100 to 400 GeV with $-t = 0.23\ 10^{-4}$ GeV^2. It is necessary to note that the values of the slope obtained in that work belong to the whole measured interval of t. Taking the afore-said into account let us compare the values of the slope of the proton-neutron scattering - B(np) with one another at different intervals of t.

For $|t| < 1.2\ 10^{-2}$ GeV^2 obtain B(np) = 13.4 ± 1.2 GeV^{-2} for $|t| < 1.6\ 10$ GeV^{-2} we have B(np) = 12.63 ± 0.78 and for all interval of t ($|t| < 0.82\ 10^{-1}$ GeV^2) B(np) = 11.64 ± 0.08. Our analysis gives for the value of the slope at the coulomb range B(pp) = 12.33 ± 0.5 at p_L = 100 GeV up 13.8 ± 0.65 at p_L = 400 GeV. The errors are sufficiently large to made a final conclusion. However, it is clear that in the neutron-proton elastic scattering there is an indication of a possible change of the value of the slope in the coulomb interaction range.

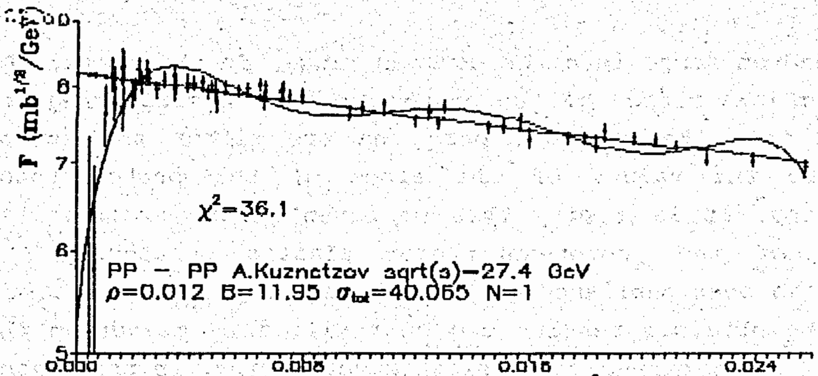

Fig. 1a |t| GeV²

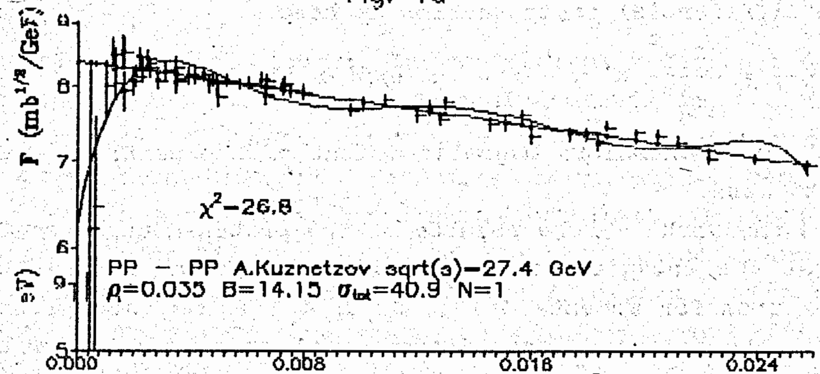

Fig. 1b |t| GeV²

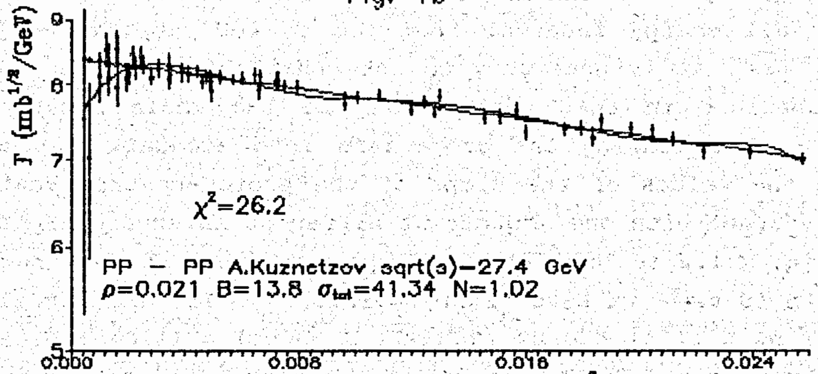

Fig. 1c |t| GeV²

Fig. 1. The imagine part of the proton-proton scattering amplitude at $\sqrt{s}$ = 27.4 GeV., straight line - the fit by the exponent with slope B, curve line - the fit by the sixth power polynomial; a) version I with the parameters taken from experimental works; b) version II with the parameters obtained by free fit; c) version III with the parameters obtained by free fit and taken into account the correction coefficient k.

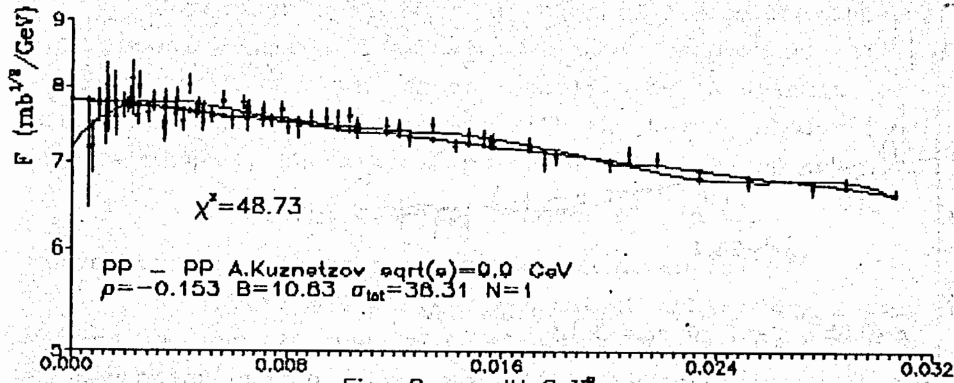

Fig. 2a |t| GeV²

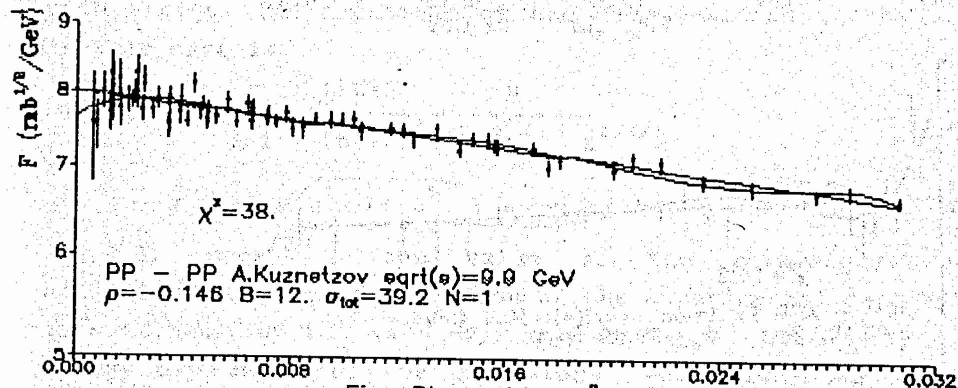

Fig. 2b |t| GeV²

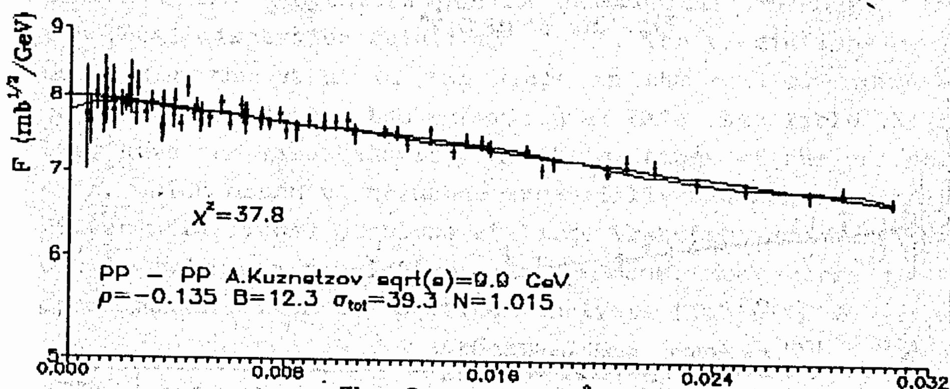

Fig. 2c |t| GeV²

Fig.2. The same thing that are in fig.1 at the $\sqrt{s}$ = 9.9 GeV.

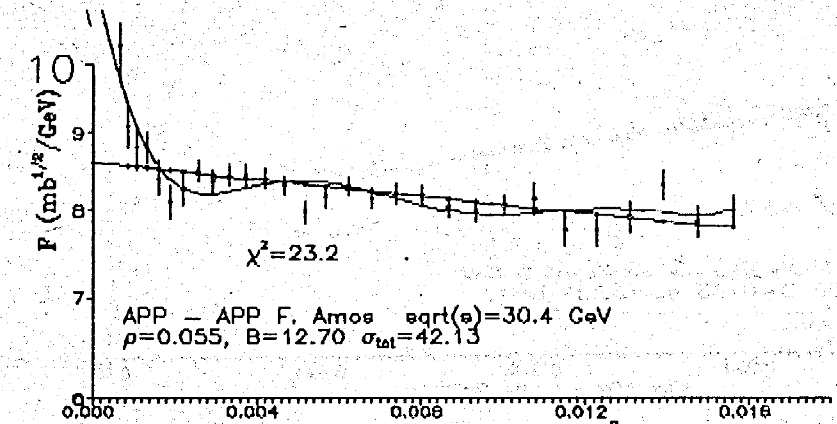

Fig. 3a |t| GeV²

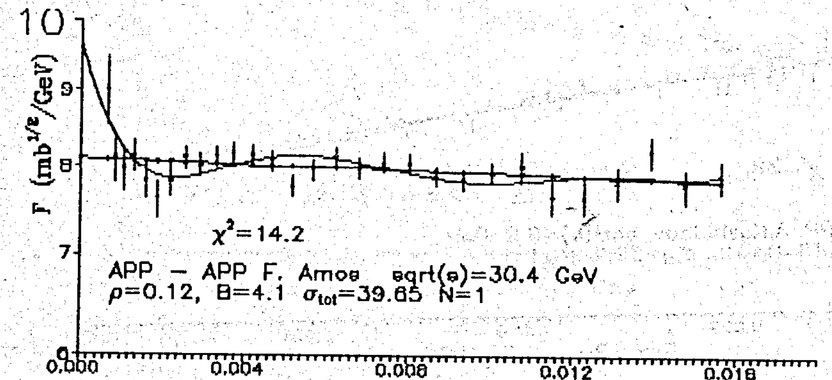

Fig. 3b |t| GeV²

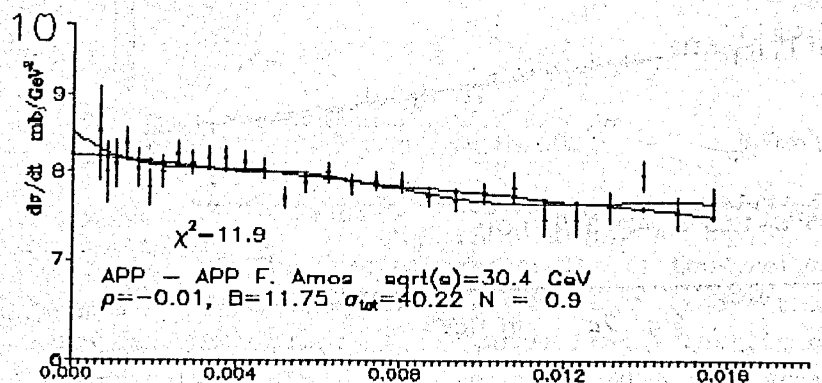

Fig. 3c |t| GeV²

Fig.3. The same thing that fig.1. for the proton-antiproton scattering at $\sqrt{s}$ = 30.4 GeV.

Note that a similar behavior of the slope appears in the models taking into account the interaction at large distances[19-22]. In these models, as a result of the consideration of the diagrams with the triangle peculiarities in t- channel, the eikonal phase is described in the form

$$\chi(s,\rho) = h \exp(\mu \, \mathrm{sqrt}(b^2 + \rho^2)), \tag{16}$$

which corresponds to the interaction potential[20]

$$V(r) = 2 \mu h / \pi * K_0(\mu \, \mathrm{sqrt}(b^2 + r^2)), \tag{17}$$

where μ and b are the effective mass and radius of interaction and h is the normalization constant which change with energy. The amplitude of the hadron-hadron interaction in this case is

$$T(s,t) = -i \sum_{n=1}^{\infty} \frac{(-h)^n}{(n-1)!} \frac{\mu}{(n^2\mu^2 + \Delta^2)^{3/2}} \cdot$$

$$* (1+b \sqrt{n^2\mu^2 + \Delta^2}) * \exp(- b \sqrt{n^2\mu^2 + \Delta^2})$$

In work[20], the value of the parameters were determined from the description of the experimental data from $\sqrt{s}$ = 23.5 GeV up to $\sqrt{s}$ = 62.2 GeV at $|t| > 0.1$ ГэВ^2. The energy dependence of the parameters was calculated on the basis of the hypothesis of the geometrical scaling[23] and the local dispersion relations[24,25]. The predictions of the model for the value of the slope in the coulomb range are somewhat larger than the experimental data (see Table IX) but they have the same behavior. A little change of the effective mass, which doesn't influence essentially the behavior of the differential cross sections at large transfer momenta, allows one to make the predictions of the model more close to the data obtained from the previous analysis (Table X)

Таблица IX

$\sqrt{s}$	$B(t_0) = d/dt\ (ln\ (d\sigma/dt))$ GeV^{-2} (μ_0 = 0.66 GeV)			
GeV	$\|t\|_0$= 0.1GeV^2	= 0.01GeV^2	= 0.001GeV^2	= 0.0001 GeV^2
13.7	12.3	14.2	14.4	14.5
52.8	13.8	16.2	16.5	16.6

Таблица X

$\sqrt{s}$	$B(t_0) = d/dt\,(ln\,(d\sigma/dt))$ GeV^{-2} (μ_0 = 0.68 GeV)			
GeV	$\lvert t\rvert_0$ = 0.1 GeV^2	= 0.01 GeV^2	= 0.001 GeV^2	= 0.0001 GeV^2
13.7	11.7	13.4	13.6	13.7
52.8	13.1	15.3	15.6	15.7

The change of $\rho(s,t)$ depending on t requires separate investigation. In work[7], the possibility of the fast growth of the real part of the scattering amplitude is shown which in its turn should influence the behavior of the imaginary part of the scattering amplitude at small transfer momenta in the precoulomb range. However, as has been noted, in the coulomb range the parameter ρ can be considered as independent of t as we don't suppose any essential peculiarities in the interaction potential at large distances.

Thus, we can make the next conclusion. The available theoretical and experimental information is insufficient for constructing on its basis rigorous theoretical models. The available experimental data indicate the continuous change of the slope B (a growth for the proton-proton scattering) in the coulomb range of the transfer momenta. There are experimental indications that $B_{PAP} \leq B_{PP}$ already at sufficiently low energies in the range of smallest t. It is possible that all these phenomena are the consequence of the oscillation of the hadron amplitude with the period depending on the transfer momenta and scattering energy In the range of $|t| \sim 0.1$ GeV^2 such oscillations were predicted[26] with a sufficiently large period with respect to t. Oscillations like those were not discovered. The explanation of the results of the work[27] was given in[28]. However, the comparison of the experimental data with the model predictions made in [28] (on fig.2) can be regarded as a possible indication of the existence of oscillations with a short period changing with t.

Thus, the necessity to carry out new, more precise experiments arises in the range of very small transfer momenta. There is a supposition that to improve the accuracy of the normalization of the differential cross sections in the coulomb range one should use the differential procedure of obtaining the corrective coefficient.

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