ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ
ДУБНА

E2 - 10971

M.I.Dzhgarkava, V.R.Garsevanishvili, L.N.Glonti,
S.V.Goloskokov, Yu.M.Kazarinov, S.P.Kuleshov,
V.A.Matveev, G.G.Macharashvili, V.K.Mitrjushkin

DESCRIPTION OF HIGH ENERGY pp-SCATTERING IN THE QUASIPOTENTIAL APPROACH

1977

E2 - 10971

M.I.Dzhgarkava, V.R.Garsevanishvili, L.N.Glonti,
S.V.Goloskokov, Yu.M.Kazarinov, S.P.Kuleshov,
V.A.Matveev, G.G.Macharashvili, V.K.Mitrjushkin

DESCRIPTION OF HIGH ENERGY pp-SCATTERING IN THE QUASIPOTENTIAL APPROACH

Submitted to "Nuclear Physics"

Джгаркава М.И. и др. **E2 - 10971**

Описание высокоэнергетического pp-рассеяния в квазипотенциальном приближении

На основе квазипотенциального подхода проводится полное описание данных (σ_{tot} , $d\sigma/dt$, $\mathcal{P}$, $\rho(0)=\frac{\mathrm{Re}\,T\ \ (s;t=0)}{\mathrm{Im}\,T\ \ (s;t=0)}$) по упругому pp-рассеянию при энергиях $E \geq 10$ ГэВ и в интервале передач $0{,}05 \leq |t| \leq 1{,}05$ (ГэВ/с)^2. Делаются предсказания относительно наблюдаемых величин.

Найдены параметры квазипотенциала, позволяющие статистически удовлетворительным образом описать эти данные.

Работа выполнена в Лаборатории теоретической физики ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1977

Dzhgarkava M.I. et al. **E2 - 10971**

Description of High Energy pp-Scattering in the Quasipotential Approach

In the paper the data(σ_{tot} , $\frac{d\sigma}{dt}$, $\mathcal{P}$, $\rho(0)=\frac{\mathrm{Re}\,T(s;t=0)}{\mathrm{Im}\,T(s;t=0)}$ on the elastic pp-scattering at energies $E_L \geq 10$ GeV and $0.05 \leq |t| \leq 1.05$ $(\mathrm{GeV}/c)^2$ momentum transfers are completely described within the quasipotential approach. The experimental quantities are predicted. The quasipotential parameters are found, which allow to describe these data satisfactorily.

The investigation has been performed at the Laboratory of Theoretical Physics, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna 1977

1. INTRODUCTION

This paper is devoted to a joint description of elastic pp-scattering data within the Logunov-Tavkhelidze quasipotential approach[1].

Recent experiments performed at accelerators of IHEP, FNAL, CERN have provided experimental information on elastic pp-scattering. For instance, this concerns the change in the slope of the peak at $|t| \sim 0.15$ $(GeV/c)^2$ [2], the growth of the ratio of the real to imaginary part of the forward scattering amplitude $\rho(0) = \mathrm{Re}\,T(s,t=0)/\mathrm{Im}\,T(s;t=0)$ up to energies $E_L \sim$ ~ 2000 GeV [3], the decrease, with energy, of spin-spin correlations at transfer momenta $|t| \lesssim 1$ $(GeV/c)^2$. Measurements of total cross sections $\sigma_{tot}(s)$ at cosmic energies (up to $E_L \sim 10^8$ GeV) indicate, evidently, the logarithmic growth of total cross sections $\sigma_{tot} \sim \ln s$ [4].

Numerous present models (for review see ref. [5,6]), as a rule, consider an incomplete set of data and cannot pretend to the consistent interpretation of the whole set of experimental regularities. Therefore, it is interesting to find a phenomenological consistent description of all experimental data (σ_{tot}, $\frac{d\sigma}{dt}$, $\rho(0)$ polarization $\mathcal{P}$, etc.). An analysis of this kind allows one to understand the structure (spin, isospin, and so on) of hadron-hadron interaction and to make predictions on observables.

To this end, it appears to be helpful to apply the hypothesis of the local smooth potential [7-10] developed in the framework of the quasipotential approach. The representation of hadron as a loose, "smeared out" object with a finite slowly increasing with energy radius leads naturally to the exponential decrease of differential cross sections as a function of t, when t is near to zero, and also, with an appropriate choice of the interaction constant, to the growth of total cross sections [10,11].

As is shown in papers [12], non-spin-flip amplitudes T_{nf}, spin-flip (T_f) and double-spin-flip amplitudes (T_{ff}), obtained by solving the quasipotential equations, are of the eikonal form in the limit of high energies and transfer momenta fixed for the local smooth potential.

In refs. [13,14] the parametrization of potential in the form of superposition of Gauss potential was successfully used for the description of πN-scattering.

In the present paper, on the basis of the asymptotic solution [12] of the quasipotential equation for two spin 1/2 particles* [16] we analyse the elastic pp-scattering in the diffraction region at $E_L \gtrsim 10$ GeV and $|t| \lesssim 1.05$ $(GeV/c)^2$ with potentials of the Gaussian type. In this study, we consider only the scalar and spin-orbital interaction in the potential for the consistent description of σ_{tot}, $\mathcal{P}$, $\rho(0)$ and $d\sigma/dt$.

Experimental data on pp-scattering were studied by other methods, as well. However, those studies have treated the data only at certain energies or in a very narrow range of momentum transfers individual characteristics of a process, and so on. The data were analysed on the basis of the theory of complex moments (allowing for moving branch points) within the so-called quasieikonal model [17].

---

* The solution of equation in the Foldy-Wouthuysen representation was considered also in ref. [15].

Within the absorptive models, the most consistent description is given in [18]. The data on σ_{tot}, $\frac{d\sigma}{dt}$ have been described within a somewhat different approach in papers [19-21].

2. SOLUTION TO THE QUASIPOTENTIAL EQUATION. CHOICE OF THE LOCAL POTENTIAL

The quasipotential equation for two spin 1/2 particles proposed in ref. [16] is of the form

$$\{E - \hat{1} \times H(-i\vec{\nabla}) - H(i\vec{\nabla}) \times \hat{1} + V(\vec{r};E)\}\Psi_p(\vec{r}) = 0, \qquad (1)$$

where

$$H(i\vec{\nabla}) = m\cdot\gamma_0 + i\alpha\vec{\nabla},$$

$$E = \sqrt{s} = 2\sqrt{m^2 + \vec{p}_i^{\,2}} = 2\sqrt{m^2 + \vec{p}_f^{\,2}}$$

is the total energy, $\vec{p}_i$ and $\vec{p}_f$ are initial and final momenta of one of the particles in the c.m.s., $t = -(\vec{p}_f - \vec{p}_i)^2$, m is the mass of colliding particles, $\hat{1}$ is the 4x4 unit matrix.

The general form of the potential includes spin-spin, spin-orbital and other interactions

$$V = V_1 + V_2(\hat{1} \times \vec{\Sigma}\vec{L} + \vec{\Sigma}\vec{L} \times \hat{1}) + \\ + \vec{V}_3\cdot\vec{\Sigma}\vec{L} \times \vec{\Sigma}\vec{L} + V_4\cdot\vec{\Sigma} \times \vec{\Sigma} + V_5\cdot\vec{\Sigma}\vec{r} \times \vec{\Sigma}\vec{r}, \qquad (2)$$

where

$$\vec{\Sigma} = \begin{pmatrix} \vec{\sigma} & 0 \\ 0 & \vec{\sigma} \end{pmatrix}$$

and $\vec{\sigma}$ are the Pauli matrices, $\vec{L} = \frac{1}{i}[\vec{r} \times \vec{\nabla}]$, γ_μ are the Dirac matrices and $\vec{a} = \gamma_0 \cdot \vec{\gamma}$.

Solving eq. (1) we will keep in the potential (2) only the terms corresponding to the scalar and spin-orbital interactions, i.e., make the following substitution

$$V = V_1 + V_2 \frac{1}{ip}(\hat{1} \times \vec{\Sigma}\vec{L} + \vec{\Sigma}\vec{L} \times \hat{1}). \tag{2'}$$

Also the scattering is considered to occur in $(x-z)$--plane.

By the method developed in ref.[8], we obtain the non-spin-flip and spin-flip amplitudes in the following form

$$T_{nf} = -ip \int_0^\infty \rho \, d\rho \, J_0(\rho\sqrt{-t}) \{ e^{\chi_{nf}(\rho)} - 1 \}$$
$$T_f = ip \int_0^\infty \rho \, d\rho \, J_1(\rho\sqrt{-t}) e^{\chi_{nf}(\rho)} \chi_f = (\sigma_y^{(1)} + \sigma_y^{(2)}) T_f' ; \tag{3}$$

where

$$\chi_{nf} = -\frac{1}{2i} \int_{-\infty}^{\infty} dz \, V_1 (\sqrt{\rho^2 + z^2} ; E)$$
$$\chi_f = -\frac{1}{2i}([\vec{\sigma}_\perp^{(1)} \times \frac{\vec{\rho}}{\rho}]_z + [\vec{\sigma}_\perp^{(2)} \times \frac{\vec{\rho}}{\rho}]_z) \cdot \int_{-\infty}^{\infty} dz \cdot (\frac{\rho}{2i} V_2 - \frac{1}{p} \cdot \frac{\partial}{\partial \rho} V_1).$$

In exp. (3) we neglect the correction terms decreasing as $1/p$ with growing $p \simeq \frac{\sqrt{s}}{2}$ relative to the leading terms. The contribution from the double-spin-flip amplitude T_{ff} is also of an order of $\sim 1/p$ as compared to T_f for potential (2') and is considered to be negligible.

The observables are expressed in terms of T_{nf} and T_f' as follows

$$\sigma_{tot} = \frac{4\pi}{p} \cdot \mathrm{Im} T_{nf}(s; t=0)$$

$$\frac{d\sigma}{dt} = \frac{\pi}{p^2}\{|T_{nf}|^2 + 2|T_f'|^2\}$$

$$\mathcal{P} = \frac{2\,\mathrm{Im}(T_{nf}^{*} \cdot T_f')}{|T_{nf}|^2 + 2|T_f'|^2}$$

$$\rho(0) = \mathrm{Re}\,T_{nf}(s;t=0)/\mathrm{Im}\,T_{nf}(s;t=0)\,. \qquad (4)$$

Keeping the hypothesis of the local smooth potential, we represent our quasipotential as a superposition of the Gaussian functions

$$V_1 = 2i \cdot g_1^{(1)} \frac{1}{a_1^{3/2}} e^{-\vec{r}^2/4a_1} +$$

$$+ (g_2^{(1)} + g_3^{(1)} \vec{r}^2)\left(\frac{\sqrt{s_0}}{p}\right)^{\xi_1} e^{-\vec{r}^2/4a_2} \quad ;$$

$$\tilde{V}_2 = \frac{\rho}{2i} \cdot V_2 - \frac{1}{p} \cdot \frac{\partial}{\partial \rho} V_1 =$$

$$= \rho\,(g_1^{(2)} + g_2^{(2)} \vec{r}^2)\left(\frac{\sqrt{s_0}}{p}\right)^{\xi_2} e^{-\vec{r}^2/4a_3} \quad ;$$

$$s_0 = 1 \ \mathrm{GeV}\,.$$

For coefficients, we choose the following energy dependence

$$a_1(s) = a_1^{(1)} + a_1^{(2)}\left(\ln\frac{s}{s_0} - \frac{i\pi}{2}\right)$$

$$g_1^{(1)} = \alpha + \beta\left(\ln\frac{s}{s_0} - \frac{i\pi}{2}\right) + \gamma\frac{1}{\sqrt{s/s_0}}\,.$$

With this choice, at sufficiently high energies, the phase $\chi_{nf}(\rho;s)$ takes the form

$$\chi_{nf}(\rho;s) = \chi_{nf}(\rho^2/a_1(s))$$

in agreement with the hypothesis of geometrical scaling. In this case total cross sections grow logarithmically.

The quantities $g_2^{(1)}$, $g_3^{(1)}$, $g_1^{(2)}$, $g_2^{(2)}$ in general, can be complex. The other parameters are put to be real.

Then, amplitudes T_{nf} and T_f' with potentials (2') can be represented in the form

$$T_{nf} = -2ia_1 p \sum_{n\geq 1} \frac{(-x)^n}{n\cdot n!} e^{t\cdot a_1/n} +$$

$$+\frac{1}{4} p\left(\frac{\sqrt{s_0}}{p}\right)^{\xi_1} \sum_{n\geq 0} \frac{(-x)^n}{n!} \cdot \frac{1}{b_n^{(1)}} \left[h_1 + \frac{h_2}{b_n^{(1)}} \cdot \left(1 + \frac{t}{4b_n^{(1)}}\right)\right] e^{t/4b_n^{(1)}} ; \tag{5a}$$

$$T_f' = -p\left(\frac{\sqrt{s_0}}{p_n}\right)^{\xi_2} \cdot \frac{\sqrt{-t}}{8i} \times$$

$$\times \sum_{n\geq 0} \frac{(-x)^n}{n!} \cdot \frac{1}{b_n^{(2)2}} \left[h_3 + h_4\left(\frac{2}{b_n^{(2)}} + \frac{t}{4b_n^{(2)2}}\right)\right] e^{t/4b_n^{(2)}} , \tag{5b}$$

where

$$x = \frac{2\sqrt{\pi}\cdot g_1^{(1)}}{a_1}$$

$$b_n^{(1)} = \frac{n}{4a_1} + \frac{1}{4a_2} ; \quad b_n^{(2)} = \frac{n}{4a_1} + \frac{1}{a_3} ;$$

$$h_1 = 2\sqrt{\pi a_2}\,(g_2^{(1)} + 2a_2 g_3^{(1)}) ;$$

$$h_2 = 2\cdot\sqrt{\pi a_2}\; g_2^{(2)}$$

$$h_3 = 2\cdot\sqrt{\pi a_3}\,(g_1^{(2)} + 2a_3 g_2^{(2)})$$

$$h_4 = 2\cdot\sqrt{\pi a_3}\; g_2^{(2)},$$

3. COMPARISON WITH EXPERIMENT AND DISCUSSION

Expressions (5a,b) were used to fit the experimental data on elastic pp-scattering in the diffraction region at $E_L \gtrsim 10$ GeV. A joint description of σ_{tot}, $\frac{d\sigma}{dt}$, $\mathcal{P}$, $\rho(0)$ was carried out. Experimental data used in the description are collected in Table 1. Parameters of the potential were determined by minimizing the function χ^2 through the standard program developed in the JINR [22]. The function χ^2 was taken in the form

$$\chi^2 = \sum_{i;k} \frac{1}{(\Delta_{i;k}^{exp})^2} [\mathcal{F}_{i;k}^{exp} - M_k \cdot \mathcal{F}_{i;k}^{theor.}]^2,$$

where $\mathcal{F}_{i;k}^{exp}$ is the quantity measured in the i-th point of the k-th experiment, $\Delta_{i;k}^{exp}$ is the experimental error of $\mathcal{F}_{i;k}^{exp}$; $\mathcal{F}_{i;k}^{theor.}$ is the theoretical curve dependent on parameters of the potential. The quantity M_k is the norm of the k-th experiment that allows one to take into account a systematic error of the k-th experiment. Norms different from unity were used only in the descritpion of differential cross sections. The norms obtained are energy-independent and more or less uniformly distributed around unity.

We neglected only the points exceeding three standard deviations. The best description was achieved for the transfer momenta $|t| \leq 0.7$ GeV^2/c^2 $\chi^2 = 527$, the number of degrees of freedom N=5 10 ($\chi^2/N \simeq 1.03$, the confidence level C.L.= 22%).

With increasing momenta up to $|t| \leq 1.05$ GeV^2/c^2 $\chi^2 = 753$ for N= 633 ($\chi^2/N \sim 1.19$).

It should be noted that the data on differential cross sections at $E_L = 200$ GeV obtained by Akerloff et al. [23] are not located on the universal curve in the coordinate system with $\frac{1}{\sigma_{tot}^2} \cdot \frac{d\sigma}{dt}$ plotted on the ordinate axis and $\sigma_{tot} \cdot |t|$ on the abscissa. The

Table 1

Fitted Experimental Data

	E_L GeV	Number of points	References
σ_{tot}	9.9÷1480	67	24,25
$\rho(0)$	9.38÷500	38	26,27,28
φ	10.	18	29
	14	18	-"-
	17.5	15	-"-
	24	9	30
	45	12	31
$d\sigma/dt$	9.9	12	32
	10	11	-"-
	10.8	13	-"-
	10.94	9	-"-
	12.0	11	-"-
	12.4	18	-"-
	12.8	13	-"-
	14.2	7	-"-
	14.8	12	-"-
	14.93	7	-"-
	15.1	20	-"-
	15.5	5	-"-
	16.7	12	-"-
	18.4	15	-"-
	18.6	4	-"-
	19.2	12	-"-
	19.6	11	-"-
	19.86	7	-"-
	20.0	19	-"-
	21.12	9	-"-
	21.4	4	-"-
	21.88	7	-"-
	24.0	15	24
	24.63	6	32
	26.2	3	-"-
	29.7	17	-"-

Table 1 (cont.)

50	49	23
100	51	23
290	32	24
500	18	24
1070	13	24
1480	9	24

inclusion of these data into the total set of the fitted exp. data worsens the description.

The values of parameters found in the fit change slightly, within the errors, with increasing momentum range from $|t| \leq 0.7$ $(GeV/c)^2$ to $|t| \leq 1.05$ $(GeV/c)^2$ (See Table 2). Parameters a_i are connected with the nucleon-nucleon interaction range which is found to be of an order of 1F.

Figures 1-13 show some curves obtained in the analysis.

Let us indicate some results of our description. The model gives growing total cross sections (see Fig. 1).

One of the qualitative results is the prediction of growing ratio $\rho(0)=\mathrm{Re}\,T_{nf}(s;t=0)/\mathrm{Im}\,T_{nf}(s;t=0)$ at positive values up to energies $E_L \leq 2111$ GeV that is in good agreement with recent data (see Fig. 2).

Figure 7 shows the dependence of the peak slope on $|t|$ at $E_L = 200$ GeV. At $|t| \sim 0.15$ GeV^2/c^2 the slope changes strongly, i.e., in this region the differential cross sections have a break.

At the energy $E_L = 45$ GeV the polarization is no longer positive throughout the whole momentum transfer range up to $|t| \leq 1$ $(GeV/c)^2$ (see Fig. 8). Predictions of our model for the polarization at $E_L = 150$ GeV are in good agreement with the recent data [33] (fig. 9).

Table 2

Parameters which are determined by fitting the experimental data, listed in Table 1

$$a_1(s)=(6{,}4\pm0{,}4)+(0{,}42\pm0{,}05)(\ln\frac{s}{s_0}-\frac{i\pi}{2})\quad(\text{GeV}/c)^{-2}$$

$$g_1^{(1)}(s)=(-0{,}8\pm0{,}2)+(0{,}192\pm0{,}003)\ (\ln\frac{s}{s_0}-\frac{i\pi}{2})+(-2{,}04\pm0{,}12)\sqrt{\frac{s_0}{s}}\quad(\text{GeV}/c)^{-2}$$

$$a_2=(5{,}84\pm0{,}18)\quad(\text{GeV}/c)^{-2}$$

$$a_3=(4{,}2\pm0{,}4)\quad(\text{GeV}/c)^{-2}$$

$$\xi_1=0{,}353\pm0{,}005$$

$$\xi_2=0{,}14\pm0{,}02$$

$$g_2^{(1)}=(-4{,}6\pm0{,}9)\cdot10^{-3}+i(0{,}050\pm0{,}002)\quad(\text{GeV}/c)^{1}$$

$$g_3^{(1)}=(-5{,}0\pm0{,}5)\cdot10^{-3}+i(7\pm0{,}75)\cdot10^{-4}\quad(\text{GeV}/c)^{2}$$

$$h_3=(1{,}33\pm0{,}2)\cdot10^{-2}+i(-4{,}8\pm0{,}3)\cdot10^{-2}\quad(\text{GeV}/c)$$

$$h_4=(-6{,}7\pm1{,}2)\cdot10^{-4}+i(-8{,}1\pm3{,}7)\cdot10^{-4}\quad(\text{GeV}/c)^{3}$$

$$S_0=1\quad(\text{GeV})^{2}$$

In Fig. 13 the amplitudes $\frac{\text{Re}}{\text{Im}}T_{nf}$ and $\frac{\text{Re}}{\text{Im}}T_{f}$ are plotted at $E_L=100$ GeV.

4. CONCLUSIONS

We have obtained the statistically satisfactory description of the experimental data on elastic pp-scattering at energies $E_L\geq 10$ GeV and momenta transfer $|t|\leq 1{,}05\ (\text{GeV}/c)^2$ within the quasipotential approach with a local smooth potential of the Gaussian type.

The predictions obtained can be used in experiments at accelerators in IHEP, FNAL, CERN.

Besides, the potentials describing the elastic hadron-hadron scattering can be used for the description of the hadron-nuclear and other scattering.

Let us discuss separately the problem of the consideration of corrections to the asymptotic expansion (3). As was indicated above, with increasing $p \sim \frac{\sqrt{s}}{2}$ the contribution of corrections is of order $\sim 1/p$ as compared to the main terms, however, at relatively low energies they can contribute to the observables. We have taken into account the corrections effectively in fitting the experimental data by renormalizing the coefficients in junior asymptotic terms of the potential.

It is not difficult to extend the scheme obtained to the description of NN-scattering allowing for the isotopic structure.

The authors are thankful to A.N.Tavkhelidze for useful remarks and also to V.R.Abasova, S.B.Nurushev, I.K.Potashnikova, A.N.Sissakian, L.A.Slepchenko and M.A.Smondyrev for discussions and help in preparing the work.

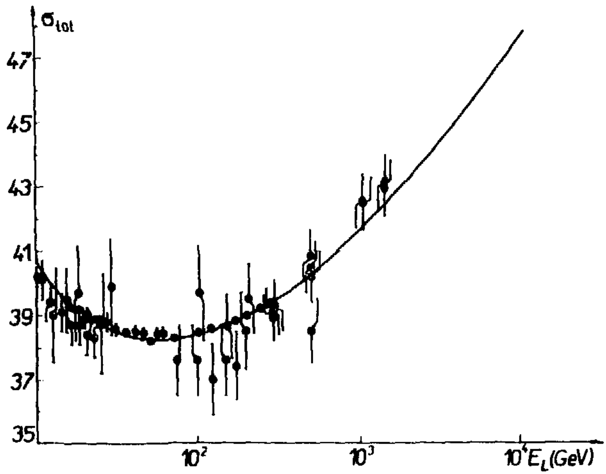


Fig. 1. Total cross sections.

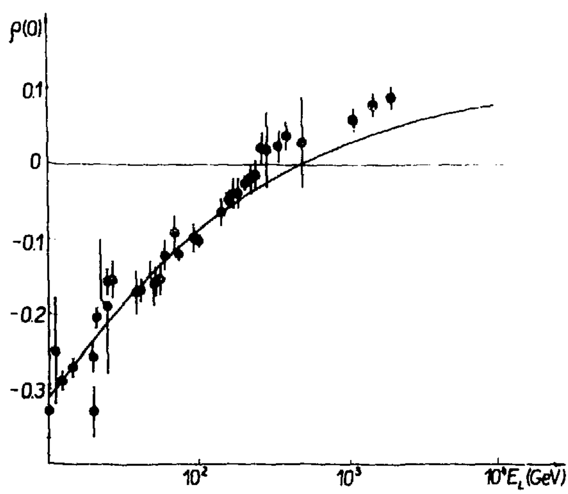


Fig. 2. Ratio $\rho(0) = \mathrm{Re}\,T_{nf}\ (s; t=0) / \mathrm{Im}\,T_{nf}\ (s; t=0)$.

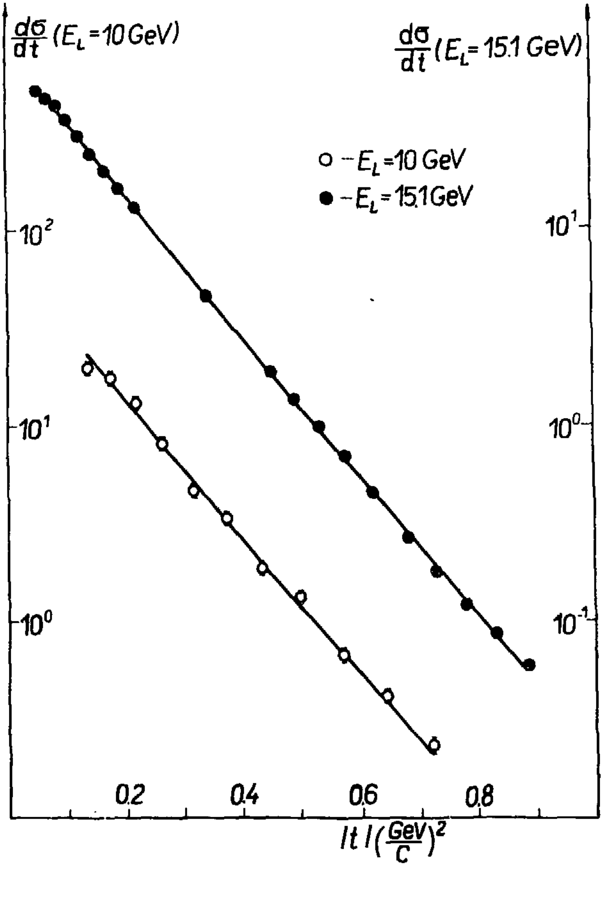


Fig. 3 . Differential cross sections at E_L = 10.0 and 15.1 GeV.

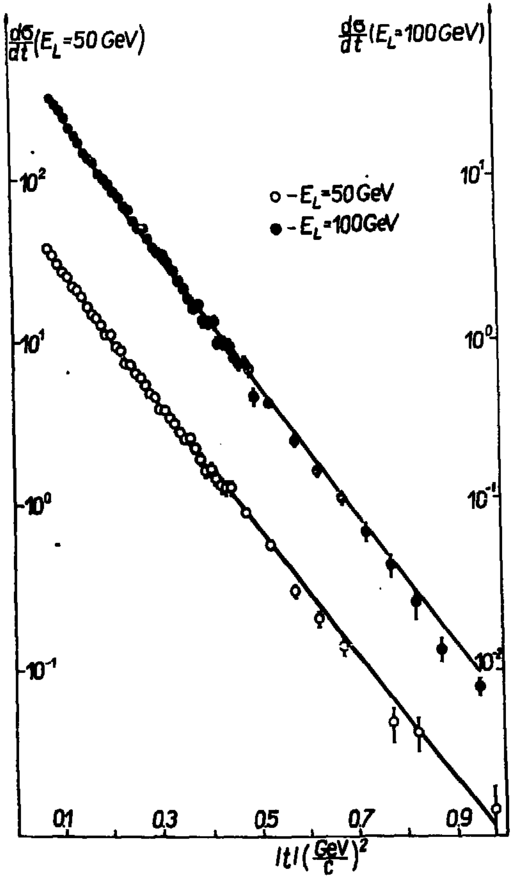


Fig. 4. Differential cross sections at E_L = 50 and 100 GeV.

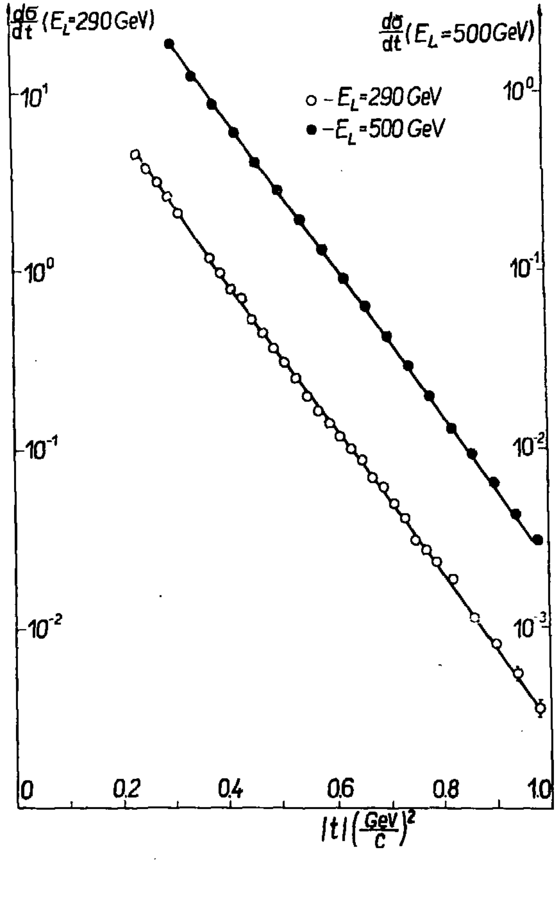


Fig. 5. Differential c oss sections at E_L=290 and 500 GeV.

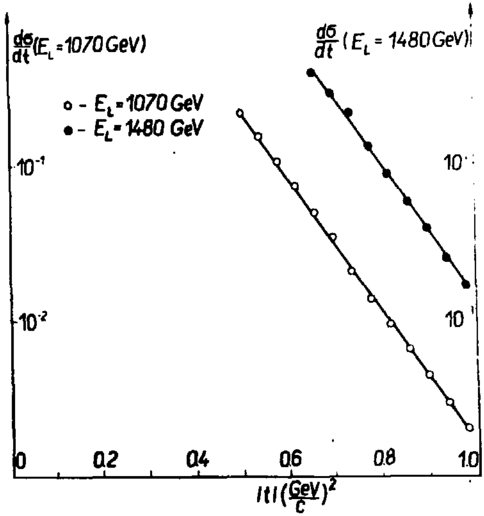


Fig. 6 . Differential cross sections at $E_L = 1070$ and 1480 GeV.

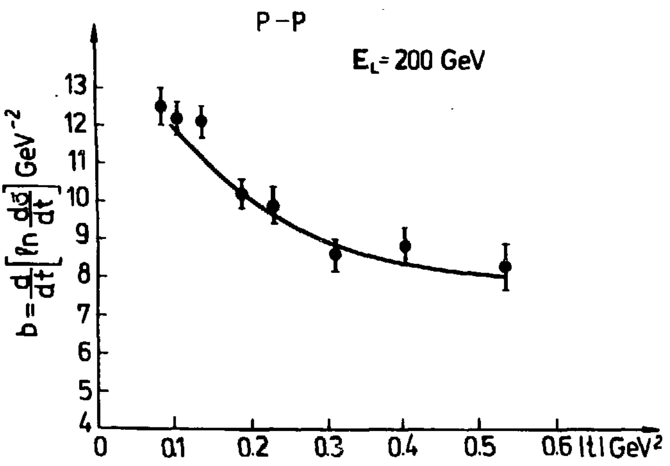
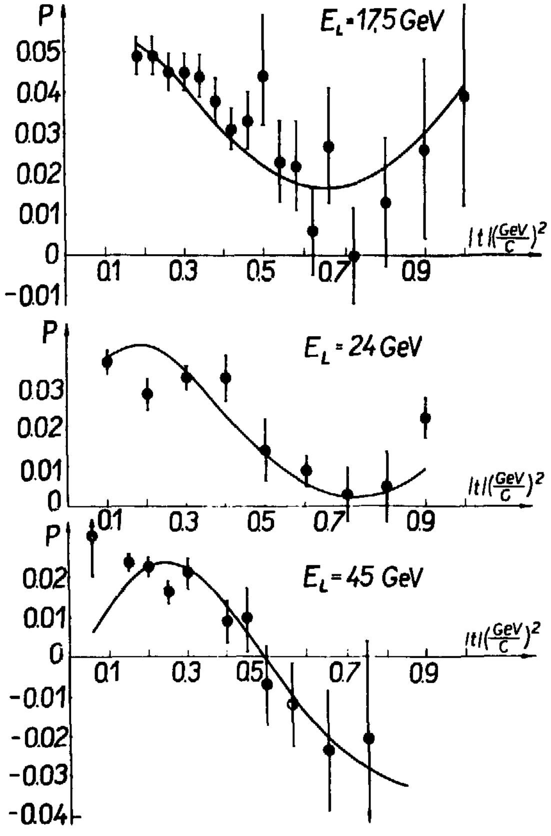


Fig. 7. Slope of the diffraction peak at $E_L = 200$ GeV.



<u>Fig. 8.</u> Polarization at E_L= 17.5 ; 24 and 45 GeV.

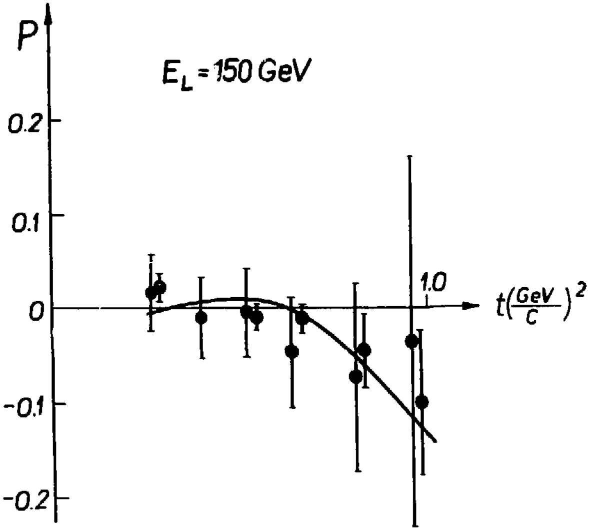


Fig. 9 . Polarization at E_L= 150 GeV. Solid curve is the prediction of our model.

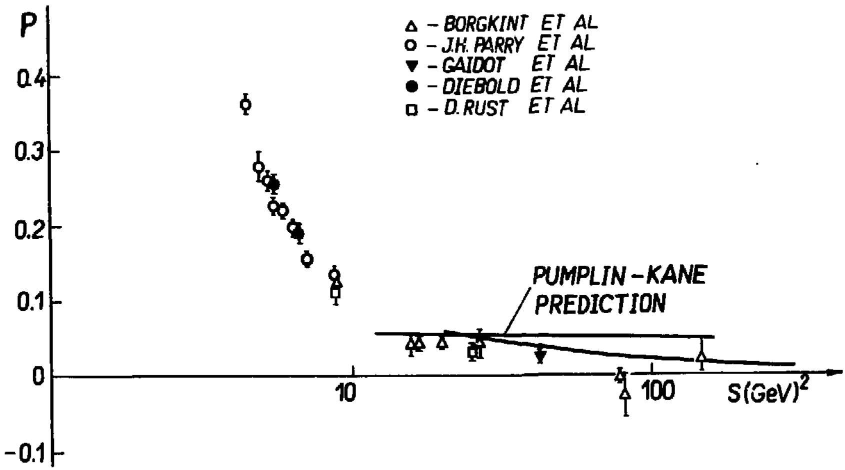


Fig. 10. Polarization at $|t| = 0.3$ $(GeV/c)^2$. The lower curve is the prediction of our model.

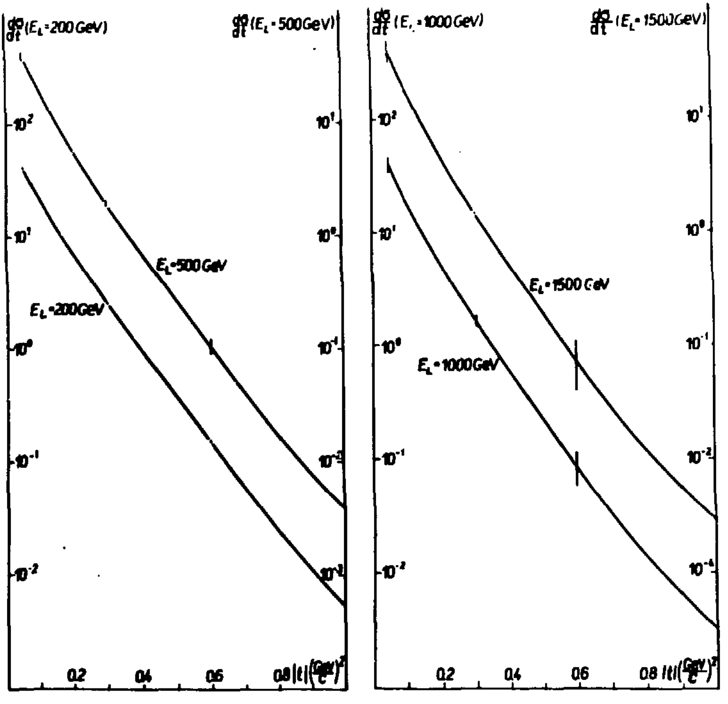


Fig. 11 . Predictions for differential cross sections at E_L=200, 500, 1000 and 1500 GeV.

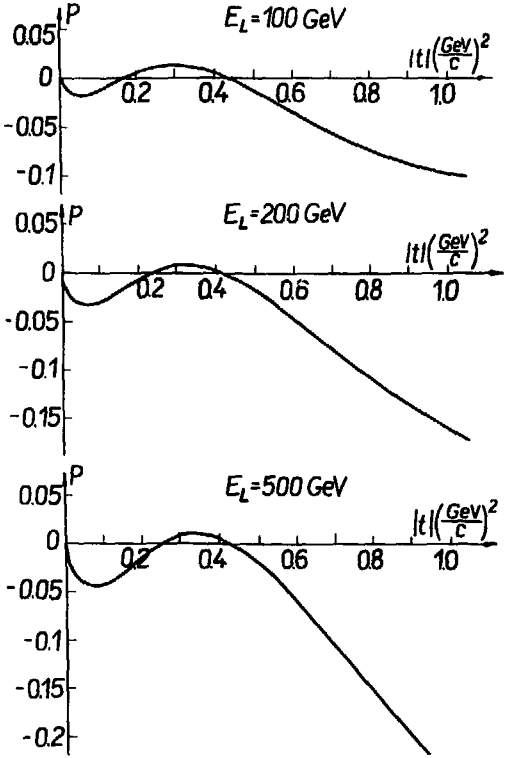


Fig. 12. Predictions for polarization at $E_L = 100$, 200 and 500 GeV.

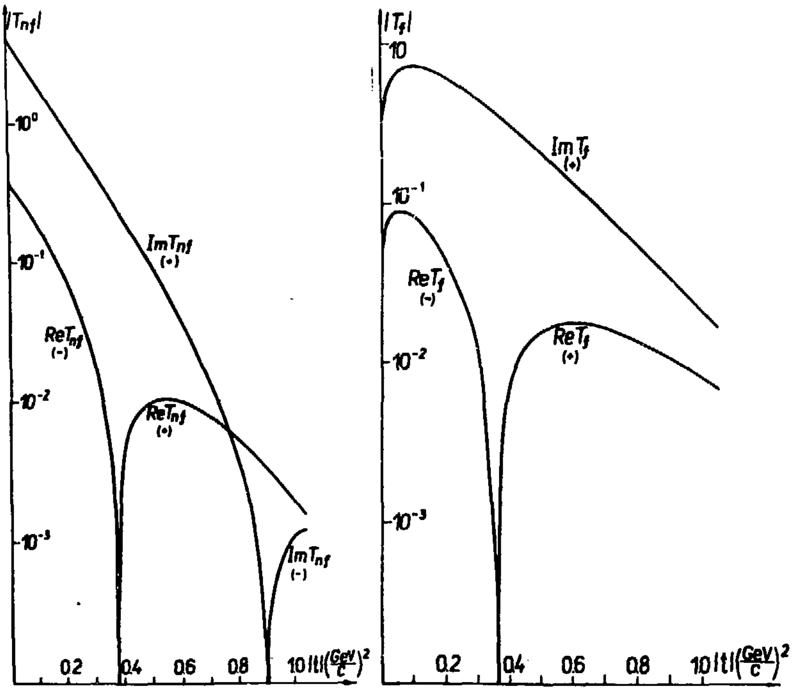


Fig. 13. Real and imaginary parts of spin-non-flip and spin-flip amplitudes at $E_L = 100$ GeV.

REFERENCES

1. Logunov A.A., Tavkhelidze A.N. Nuovo Cim., 1963, 29, p.380.
Tavkhelidze A.N. Lectures on Quasipotential Method in Field. Theory. Tata Institute of Fundamental Research, Bombay, 1964.
2. Ankenbrandt C. et al. Submitted to the XVIII Int. Conf. on High Energy Physics, Tbilisi, July, 1976, N 1242/A1-167.
3. Amaldi U. et al. Phys.Lett., 1977, 66B, p.390.
4. Dremin I.M. JINR, D1,2-10400, Dubna, 1977, p. A3-31.
5. Matveev V.A. JINR, D1,2-10400, Dubna, 1977, p.A5-34.
6. Kajdalov A.B. JINR, D1,2-10400, Dubna, 1977, A1-27.
7. Blokhintsev D.I. Nucl.Phys., 1962, 31, p.628.
8. Khrustalev O.A., Savrin V.I., Tyurin N.Ye. JINR, E2-4479, Dubna, 1969.
9. Barbashov B.M. et al. Nuovo Cim., 1971, 4A, p.182.
10. Alliluyev S.P., Gershtein S.S., Logunov A.A. Phys.Lett., 1965, 18, p.195.
11. Mestvirishvili M.A., Rcheushvili G.L. Yad.Fiz., 1970, 11, p.688.
12. Goloskokov S.V. et al. JINR, P2-8338, Dubna, 1974; JINR, P2-8339, Dubna, 1974; TMP, 1975, 24, p.147.
13. Dzhgarkava M.I. et al. Nucl.Phys., 1973, B67, p.232.
14. Dzhgarkava M.I. et al. JINR, P2-9947, Dubna, 1976.
15. Garsevanishvili V.R., Goloskokov. JINR, P2-9163, Dubna, 1976.
16. Khelashvili A.A., JINR, P2-4327, Dubna, 1969.
17. Yeremyn Sh.S. Yad.Fiz., 1974, 20, p.1051.
18. Kane G.L., Seidl A. Rev. of Mod.Phys., 1976, 48, p.309.
19. Aleksandrov A., Mavrodiev S. JINR, E2-9936, Dubna, 1976.
20. Starkov N.I., Tzarev V.A., Zotov N.P. Kratkie soobsh. po phys., PhiAN, no. 12, 3 (1975).

21. Semenov S.V., Tyurin N.E. Yad.Fiz., 1974, 21, p.1316.
22. Silin I.N. JINR, 11-3362, Dubna, 1969.
23. Akerloff C.W. et al. Phys.Rev., 1976, 14D, p.2864.
24. "Particle Data Group. Compilation of Cross Sections". CERN/HERA 73-1 (1973).
25. Carrol A.S. et al. Phys.Lett., 1976, 61B, p.303; 1976, 62B, p.460.
26. Foley K.J. et al. Phys.Rev.Lett., 1967, 19, p.857.
27. Beznogikh G.G. et al. Phys.Lett., 1972, 39B, p.411.
28. Bartenev V. et al. Phys.Rev.Lett., 1967, 31, p.1367. JINR, E1-9090, Dubna, 1975.
29. Borghini M. et al. Phys.Lett., 1970, 31B, p.105.
30. Crabb D.G. et al. Nucl.Phys., 1977, 121B, p.231.
31. Gaidot A. et al. Phys.Lett., 1976, 61B, p.103.
32. "Particle Data Group. NN and ND Interactions - a Compilation. UCRL-20000 NN (1970).
33. Fidecaro G. et al. CERN Preprint, 1977.

Received by Publishing Department
on September 20, 1977.