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THE BEHAVIOR OF THE SLOPE OF ELASTIC NUCLEON SCATTERING AT SMALL TRANSFER MOMENTA AND RECENT UA4/2 DATA

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An actual problem of the modern physics of elementary particles, the research of strong interaction processes at large distances and high energies, is considered in the framework of different approaches by using various models of the structure of hadrons and the dynamics of their interactions (see e.g. [1]). The diffraction scattering cannot yet be described quantitatively in the framework of the perturbative QCD. Therefore, it is necessary to apply the different models which can describe the hadron-hadron interaction at large distances [2]. The research of elastic scattering requires the knowledge of properties of the pomeron, the object determining the interaction of hadrons in this range. In this case the study of the structure and spin properties of both the hadron and the pomeron acquires a special role. In a number of works [3-5] the dynamical model with taking account of the interaction at large distances has been developed. The model is based on the general quantum field theory principles (analyticity, unitarity and so on) and takes into account basic information on the structure of a hadron as a compound system with a central part region where the valence quarks are concentrated and a long-distance region where the color-singlet quark-gluon field occurs.

Let us consider the nucleon-nucleon scattering. In [4] on the basis of sum rules it has been shown that the main contribution to hadron interaction at large distances comes from the triangle diagram with 2π -meson exchange in the t-channel. As a result, the hadron amplitude can be represented as a sum of central and peripheral parts of the interaction:

$$T(s,t) \propto T_c(s,t) + T_p(s,t) \qquad (1)$$

where $T_c(s,t)$ describes the interaction between the central parts of hadrons; and $T_p(s,t)$ is the sum of contributions of diagrams corresponding to the interactions of the central part of one hadron on the meson cloud of the other. The contribution of these diagrams to the scattering amplitude with an $N(\Delta\text{-isobar})$ in the intermediate state looks as follows [5]:

$$T^{\lambda_1\lambda_2}_{N(\Delta)}(s,t) = \frac{g^2_{\pi NN(\Delta)}}{i(2\pi)^4}\int d^4q T_{\pi N}(s,t)\varphi_{N(\Delta)}[(k-q),q^2]\varphi_{N(\Delta)}[(p-q),q^2]$$
$$\times\frac{\Gamma^{\lambda_1\lambda_2}(q,p,k,)}{[q^2-M^2_{N(\Delta)}+i\epsilon][(k-q)^2-\mu^2+i\epsilon][(p-q)^2-\mu^2+i\epsilon]}. \qquad (2)$$

Here λ_1, λ_2 are helicities of nucleons; $T_{\pi N}$ is the πN-scattering amplitude; Γ is a matrix element of the numerator of the representation of the diagram ; φ are vertex functions chosen in the dipole form with the parameters $\beta_{N(\Delta)}$:

$$\varphi_{N(\Delta)}(l^2, q^2 \propto M^2_{N(\Delta)}) = \frac{\beta^4_{N(\Delta)}}{(\beta^2_{N(\Delta)} - l^2)^2}. \qquad (3)$$

The model with the N and Δ contribution provides a self-consistent picture of the differential cross sections and spin phenomena of different hadron processes at high energies. Really, parameters in the amplitude determined from one reaction, for example, elastic pp-scattering, allow one to obtain a wide range of results for elastic meson-nucleon scattering and charge-exchange reaction $\pi^- p \to \pi^0 n$ at high energies.

It is essential that the model predicts large polarization effects for all considered reactions at high and superhigh energies [5]. The predictions are in good agreement with the experimental data in the energy region available for experiment. Also note that just the effect of large distances determines a large value of the spin-flip amplitude of the charge-exchange reaction [6].

The model takes into account the $s \to u$ crossing diagrams in the scattering amplitude, which leads to the asymptotic equality of the proton-proton and proton-antiproton cross sections as $s \to \infty$. An important property of this model is that it can be applied to the proton-antiproton scattering at sufficiently low energies. Thus, the behavior of the proton-proton and proton- antiproton differential cross sections at $p_L = 40GeV$ and $p_L = 1850GeV$ acquires a natural explanation [7].

The model gives the universal behavior of the diffraction peak slope for all hadron reactions [4]. More than a decade, the description of the proton-proton scattering at small transfer momenta and energies of ISR showed the possibility of oscillations of the differential cross sections with a small amplitude about several percent [8]. A more careful analysis of the differential cross sections in the coulomb region of transfer momenta also revealed this possibility [9]. At the same time, the model gave the understanding of the effect of oscillation revealed in [10]. Such big oscillations are caused by changing the slope of the differential cross sections with transfer momenta, on the one hand, and its description in terms of the exponential form, on the other hand [8]. The predictions of the model in the range of the second diffraction peak coincide with the experimental data at $\sqrt{s} = 630GeV$ [11].

Now let us compare our model predictions [3, 11, 5] with the recent data of UA4 collaboration [12]. The data are very precise and give errors only of several percent. The model predictions for the behavior of the slope of the diffraction peak made for $\sqrt{s} = 540GeV$ give $B(s,t) = 15.5GeV^{-2}$ at $0 < |t| < .15GeV^2$ and $\rho(s,t) = ImT(s,t)/ReT(s,t) = .14$ at $|t| = .001GeV62$.

As can be seen from figure, the model predictions are in good agreement with the new experimental data. We obtain $\chi^2/2N = 158/99$ with no change of model parameters. However, as the value of the cross sections in the model was normalized to the experimental data in the range of energies of ISR which have the bias errors about 10 -20 percent, we can insert a further norm about 5 percent into our model predictions. Then, $\chi^2/2N = 102/99$. It should be noted that in the range of small transfer momenta the model leads to a smooth change of the slope of the differential cross sections with growing $|t|$. For the energy range under discussion we have the following value of the slope (see Table).

Our predictions for the range of small transfer momenta at $\sqrt{s} = 1.8TeV$ are shown in figure.The values of the parameters $\rho(s,t)$ and $B(s,t)$ for that energy are also presented in Table. As is obvious from Table, both $\rho(s,t)$ and $B(s,t)$ depend heavily on s and t.

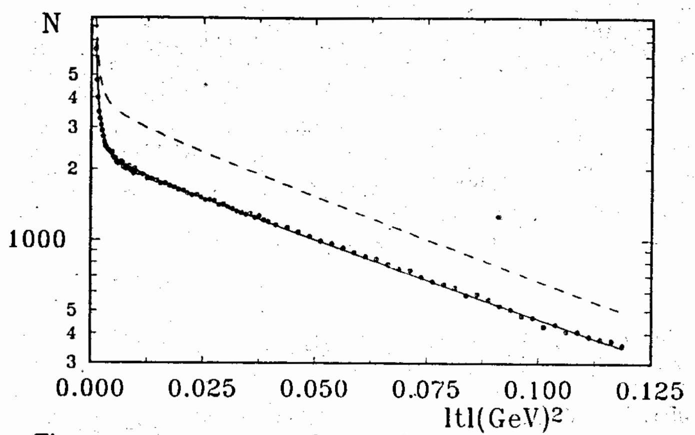

Figure : ———— the model predictions for $\bar{p}p$ - scattering,
ɋ - the experimental unnormalized data UA4 [12],
- - - - - - - - - - our predictions at $\sqrt{s} = 1.8TeV$

TABLE

$-t$	$\sqrt{s} = 541GeV$		$\sqrt{s} = 1800GeV$	
GeV^2	$\rho(s,t)$	$B(s,t)GeV^{-2}$	$\rho(s,t)$	$B(s,t)GeV^{-2}$
.001	.141	16.8	.182	18.1
.014	.135	16.5	.178	17.7
.066	.112	15.5	.161	16.6
.120	.089	14.9	.143	15.9

At this energy we can see some oscillations of the cross sections with a very small amplitude and the period depending on transfer momenta. Now we can only remark that the possibility of existence of such oscillations requires more careful theoretical and experimental research.

The results which rather well describe the experimental data at $\sqrt{s} = 540GeV$ were obtained in the model [13]. Note that like all modifications of the Chow-Yang model, it predicts the appearance of a strongly marked diffraction structure at superhigh energies. We must emphasize that only our model gives such a large growth both of differential and total cross sections and has no sharp dips in the cross sections at superhigh energies.

Thus, it is clear that the most distinctive predictions of different models belong to the range of $|t| \sim 1.GeV^2$. So, our prediction for the cross section at $\sqrt{s} = 2.TeV$ and $|t| = 1.GeV^2$ is $d\sigma/dt = 0.0213mb/GeV^{-2}$ [4] and the prediction of the model [13] $d\sigma/dt = 0.0112mb/GeV^{-2}$. The difference of model predictions in the range of small transfer momenta is basically in the values of $\rho(s,t)$ and its dependence on s

and t. It should be noted that the change of the parameters of the differential cross sections at small transfer momenta requires a very careful analysis of the procedure of determining these parameters, especially in obtaining the value of the total cross sections [9] as well as further theoretical research and measurement of the differential cross sections in the coulombic range of superhigh energies.

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Голоскоков С.В., Кулешов С.П., Селюгин О.В. **E2-93-433**

Поведение наклона упругого нуклонного рассеяния при малых передачах импульса и последние данные UA4/2

Предсказания динамической модели для поведения наклона и других параметров дифференциальных сечений сопоставляются с последними данными коллаборации UA4/2 в области малых передач импульса и энергии в системе центра масс,равной 541 ГэВ. Рассматриваются предсказания на сверхвысокие энергии.

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The Behavior of the Slope of Elastic Nucleon Scattering at Small Transfer Momenta and Recent UA4/2 Data

Theoretical predictions for the behavior of the slope of the nucleon-nucleon scattering and other parameters of the differential cross sections in the framework of the dynamic model are compared with the recent UA4/2 data at small transfer momenta and at a centre-of-mass energy of 541 GeV. Predictions at superhigh energies are considered.

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

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