The phenomenon of antiscreening in inelastic diffraction of hadrons by nuclei

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Inelastic diffraction in nuclei is discussed in the eigenstate model, which correctly describes the space-time structure of the interaction. It is shown that the eigenstate model is equivalent to the multiple-scattering model, in which all intermediate states are taken into account. In the quark-parton variant of the eigenstate model it is found that the imaginary part of the inelastic diffraction amplitude is negative, in contrast to the elastic diffraction amplitude. This leads to the result that certain graphs in the multiple-scattering model have an anomalous sign—the phenomenon of antiscreening. Data on the reaction $pd \to Xd$ clearly confirm this conclusion. Neglect of antiscreening corrections has been the reason that the cross sections for absorption of hadrons produced by diffraction in nuclei have turned out to be highly underestimated.

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1. INTRODUCTION

The picture of occurrence of inelastic diffraction as the result of absorption was first proposed by Feinberg and Pomeranchuk[1] and subsequently developed by Good and Walker.[2] In previous articles[3,4] we have applied these ideas in terms of the quark-parton model to elastic hadron-nucleus scattering. It was shown that this eigenstate method (ESM) is equivalent to the multiple-scattering model (MSM), in which all intermediate states have been taken into account. This results is generalized to the case of inelastic diffraction in Section 2 of the present work. In Section 3 we consider a simplified variant of the ESM in which in the parton model we distinguish only two eigenstates of the interaction: active and passive. Here it is shown that the imaginary part of the inelastic diffraction amplitude is negative. This leads to the result that certain Feynman graphs in the MSM which contain an even number of inelastic vertices have an anomalous sign.

This pehnomenon is discussed in detail in Section 4 for the case of the deuteron. It is shown that as the result of antiscreening the total correction corresponding to double rescattering in the process $pd\to Xd$ should change sign with increase of M_X^2. This prediction is confirmed by analysis of the experimental data.

One of the important consequences of antiscreening concerns the method of determining the cross sections for absorption of unstable hadronic systems produced in inelastic diffraction reactions in nuclei. If graphs containing more than one inelastic vertex are neglected in a theoretical analysis (this is often done), the cross section obtained from these data for absorption of the produced hadrons in the nucleus will turn out to be greatly underestimated. For a long time the results of incorrect analyses of this type have been treated as a physical phenomenon. A discussion of these questions is given in Section 5.

In Section 6 we consider a number of other consequences of the negative sign of the imaginary part of the inelastic diffraction amplitude.

2. EIGENSTATE METHOD AND MULTIPLE-SCATTERING MODEL

We shall consider inelastic diffraction in nuclei in terms of the eigenstate model developed previously[3,4] for elastic scattering. We introduce a set of eigenstates $|k\rangle$ of the interaction Hamiltonian ($k=0,1,2,\ldots$ are the numbers of the states). Under the action of $\hat{f}$—the imaginary part of the scattering amplitude operator—the state $|k\rangle$ goes over to

$$\hat{f}|k\rangle=f_k|k\rangle. \tag{1}$$

The physical states $|\alpha\rangle$—the eigenstates of the vacuum—are related to $|k\rangle$ by the unitary transformation

$$|\alpha\rangle=\sum_k c_{\alpha k}|k\rangle, \tag{2}$$

$$\sum_k c_{\alpha k}c_{k\beta}^*=\delta_{\alpha\beta}, \tag{3}$$

$$\sum_\alpha c_{k\alpha}^*c_{\alpha i}=\delta_{ik}. \tag{4}$$

The scattering amplitude in this basis has the form[5]

$$f_{\alpha\beta}^{(1)}=\langle\beta|\hat{f}|\alpha\rangle=\sum_k c_{\alpha k}c_{k\beta}^*f_k. \tag{5}$$

In the case in which the target contains two scattering centers (a deuteron), the correction for double rescattering has the form

$$f_{\alpha\beta}^{(2)}=\sum_k c_{\alpha k}c_{k\beta}^*f_k^2. \tag{6}$$

Here we have taken into account that for the states $|k\rangle$ there exists only Glauber rescattering. In addition it is assumed that the energy of the scattered particle is sufficiently large that the time of the hadronic flucturations of the state $|\alpha\rangle$ with allowance for Lorentz dilation is significantly greater than the interaction time, i.e., the states $|k\rangle$ in Eq. (2) are not mixed in the scattering process.[3,4]

In the multiple-scattering model, graphs with intermediate states $|\alpha\rangle$, $|\beta\rangle$ (corrections of the Glauber type) or $|\gamma\rangle\neq|\alpha\rangle$, $|\beta\rangle$ (inelastic corrections[6]) are taken into account. Each of these graphs is inconsis-

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tent with the space-time picture of the interaction, but the total sum of these graphs leads to a correct result. In fact, using Eq. (4), we obtain

$$\sum_{\gamma} f_{\alpha\gamma}^{(1)} f_{\gamma\beta}^{(1)} = \sum_{\gamma} \Big(\sum_{k} c_{\alpha k} c_{k\gamma}^{*} f_k \Big) \Big(\sum_{m} c_{\gamma m} c_{m\beta}^{*} f_m \Big) = \sum_{k} c_{\alpha k} c_{k\beta}^{*} f_k^2. \quad (7)$$

This proof is easily extended to the case of an arbitrary nucleus. It is a generalization of the results obtained previously[3,4] for elastic scattering.

3. THE SIGN OF THE INELASTIC DIFFRACTION AMPLITUDE

The positive nature of the imaginary part of the elastic scattering amplitude $f_{\alpha\alpha}(b)$ (in the impact-parameter representation) follows from the unitarity relation. Unfortunately there are not at the present time any principles which permit determination of the sign of the inelastic diffraction amplitude. We shall attempt to do this, using the eigenstate method in the parton model. In Refs. 3 and 4 we showed that the main contribution to the inelastic diffraction amplitude is due to the difference between the amplitude f_0 of scattering in the passive state (k is the number of slow partons) and the amplitude f_k with $k \geqslant 1$. The dispersion of the amplitudes f_k in the active component gives a small correction to the cross section for inelastic diffraction,[4] since all of the amplitudes f_k with $k \geqslant 1$ will be assumed equal and will be designated by F. Here the scattering matrix in the basis of the interaction eigenstates $|k\rangle$ takes the form

$$\langle k|f|i\rangle = F\delta_{ik} - (F - f_0)\delta_{i0}\delta_{k0}.$$

Going over to the eigenstates of the vacuum, we obtain

$$f_{\alpha\beta} = \sum_{ik} c_{\alpha i} f_{ik} c_{k\beta}^{*} = F\delta_{\alpha\beta} - (F - f_0) c_{\alpha 0} c_{0\beta}^{*}. \quad (8)$$

Consequently the amplitudes of elastic and inelastic diffraction have the form

$$f_{\alpha\alpha} = (1 - |c_{\alpha 0}|^2)F + |c_{\alpha 0}|^2 f_0, \quad (9)$$

$$f_{\alpha\beta} = -c_{\alpha 0} c_{0\beta}^{*} (F - f_0). \quad (10)$$

Since the scattering amplitude in the passive state is $f_0 = 0$, we have $f_{\alpha\alpha} = P_\alpha F$, where P_α is the norm of the active component $|\alpha\rangle$ (Refs. 3 and 4). In the quark-parton model[3,4] we have $c_{\alpha 0} = (c_{q0})^{n}\alpha$, where c_{q0} is the coefficient for the passive component of the constituent quark; n_α is the number of constituent quarks and antiquarks in the state $|\alpha\rangle$. The states $|\alpha\rangle$ and $|\beta\rangle$ differ in the number of quark-antiquark pairs. As a result of the fact that the states $|q\rangle$ and $|\bar{q}\rangle$ have opposite phases, the phases of the coefficients $c_{\alpha 0}$ and $c_{\beta 0}$ are identical, so that the diffraction amplitude (10) has a negative sign.

In order to be convinced of this result, it is necessary to study interference effects in which the sign of $f_{\alpha\beta}$ appears explicitly.

4. THE PHENOMENON OF ANTISCREENING

The negative sign of the inelastic diffraction amplitude leads to the result that certain graphs in the multiple-scattering model acquire a sign different from that in the Glauber model. We shall consider in detail inelastic diffraction scattering in the deuteron.

The diffraction amplitude $f_{\alpha\beta}$ in the multiple-scattering model is the sum of the diagrams shown schematically in Fig. 1. It follows from the results of the preceding section that the correction term $f_{\alpha\gamma\beta}^{(2)}$, where $\gamma \neq \alpha, \beta$, has the same sign as the impulse term $f_{\alpha\beta}^{(1)}$. Therefore the contribution of $f_{\alpha\gamma\beta}^{(2)}$ to the diffraction amplitude is antiscreening in nature, in contrast to the corrections of the Glauber type $f_{\alpha\alpha\beta}^{(2)}$ and $f_{\alpha\beta\beta}^{(2)}$. The sign of the combined correction for double rescattering $f_{\alpha\beta}^{(2)} = f_{\alpha\alpha\beta}^{(2)} + f_{\alpha\beta\beta}^{(2)} + f_{\alpha\gamma\beta}^{(2)}$ depends on the relative size of the terms. We note further that the longitudinal momentum transfer $q_\parallel$ in diagrams c and b of Fig. 1 is perceived by the deuteron only at the one vertex $\alpha \to \beta$. At the same time in diagram d the momentum transfer $q_\parallel$ is distributed between the vertices $\alpha \to \beta$ and $\gamma \to \beta$. Therefore with increase of $q_\parallel$ the relative contribution to $f_{\alpha\beta}^{(2)}$ of diagrams c and b is suppressed by the deuteron form factor. Consequently at a sufficiently large value of $q_\parallel$ the term $f_{\alpha\gamma\beta}^{(2)}$ begins to dominate in $f_{\alpha\beta}^{(2)}$, which in this case should change the sign in accordance with the discussion above.

To check this prediction, let us consider the following combination of the experimental data:

$$R(x, q^2) = 1 - \frac{d^2\sigma(pd \to dX)/dq^2 dx}{4S^2(q^2/4)\, d^2\sigma(pp \to pX)/dq^2 dx}. \quad (11)$$

Here $-q^2$ is the squared four-momentum transfer, $x \approx 1 - M_x^2/s$ is the invariant Feynman variable, M_X is the effective of the state X, s is the square of the total energy in the c.m.s. (in the reaction $pd \to dX$ the quantity s must be calculated for the NN system), and $S(q^2)$ is the deuteron form factor.

Equation (11) can be written in the multiple-scattering model as follows:

$$R(x, q^2) = -2f_{\alpha\beta}^{(2)}/f_{\alpha\beta}^{(1)} - (f_{\alpha\beta}^{(2)}/f_{\alpha\beta}^{(1)})^2. \quad (12)$$

It can be seen from this that if $f_{\alpha\beta}^{(2)}$ changes sign with increase of $q_\parallel$, then the function $R(x, q^2)$ also should change sign with increase of $1 - x \approx q_\parallel/m_N$.

The values of $R(x, q^2)$ obtained from the experimental data[7] on the reaction $pd \to dX$ are given in Fig. 2. For the cross section for the reaction $pp \to pX$ we used the

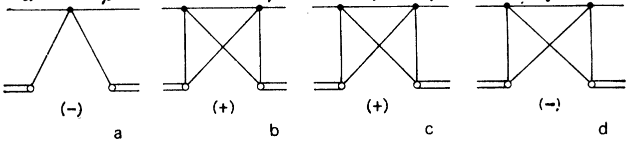

FIG. 1. Feynman diagrams describing various contributions to the inelastic diffraction amplitude. The signs of the imaginary parts of these contributions are given in parentheses.

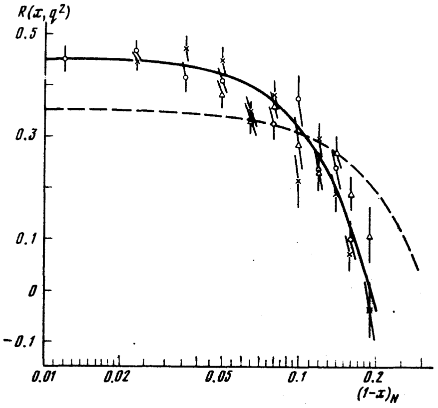

FIG. 2. The function $R(x,q^2)$ [$q^2=-0.13$ (GeV/c)^2], calculated according to Eq. (11) with use of the data of Ref. 7 for the reaction $pd\to Xd$ and the results of description of the data on $pp\to pX$ in Ref. 8; △—$s_N=124$ GeV^2, ×—$s_N=291$ GeV^2, ○—$s_N=700$ GeV^2. The dashed curve is the result of a calculation with a fixed value $\varkappa=1$ and one free parameter; the value $\delta=2.34\pm0.14$ corresponds to the best description. The solid curve is the best description with two free parameters: $\varkappa=1.56\pm0.037$ and $\delta=4.46\pm0.12$.

results of a triple-Reggeon description[8] of the experimental data (with subtraction of the contribution of pion exchange).

We shall now make numerical estimates of the function $R(x,q^2)$. The combined contribution of diagrams c and b of Fig. 1 to the diffraction amplitude can be written in the form[9]

$$f_{\alpha\alpha\beta}^{(2)}+f_{\alpha\beta\beta}^{(2)}=-\frac{\delta}{8\pi^2}\int d^2k_\perp f_{\alpha\beta}{}^N\left(\frac{1}{2}q_\perp+k_\perp,q_\parallel\right)\times f_{\alpha\alpha}{}^N\left(\frac{1}{2}q_\perp-k_\perp,0\right)S\left(\frac{1}{4}q_\parallel{}^2+k_\perp{}^2\right). \tag{13}$$

Here $q_\perp$ and $q_\parallel$ are the transverse and longitudinal components of the momentum transfer q; $\delta=1+\sigma_{\text{tot}}^{\beta N}/\sigma_{\text{tot}}^{\alpha N}$; $f_{\alpha\alpha}^N$ and $f_{\alpha\beta}^N$ are the amplitudes of elastic and inelastic diffraction by a nucleon. It is assumed that the amplitudes $f_{\alpha\alpha}^N$ and $f_{\beta\beta}^N$ have an identical dependence on q^2.

The dependence $S(k_\perp^2)$ is so steep that the remaining functions in Eq. (13) can be taken outside the integral sign and we can set $k_\perp^2=0$ in them:

$$f_{\alpha\alpha\beta}^{(2)}+f_{\alpha\beta\beta}^{(2)}=-\frac{\delta}{8\pi^2}f_{\alpha\beta}{}^N\left(\frac{1}{2}q_\perp,q_\parallel\right)f_{\alpha\alpha}{}^N\left(\frac{1}{2}q_\perp,0\right)\times\int d^2k_\perp S\left(\frac{1}{4}q_\parallel{}^2+k_\perp{}^2\right). \tag{14}$$

In a similar manner we can estimate the quantity $f_{\alpha\gamma\beta}^{(2)}$:

$$f_{\alpha\gamma\beta}^{(2)}=-\frac{1}{16\pi^3}f_{\alpha\gamma}{}^N\left(\frac{1}{2}q_\perp,\frac{1}{2}q_\parallel\right)f_{\gamma\beta}{}^N\left(\frac{1}{2}q_\perp,\frac{1}{2}q_\parallel\right)\times\int d^2k_\perp dk_\parallel S(k_\perp{}^2+k_\parallel{}^2). \tag{15}$$

The impulse term in the diffraction amplitude is

$$f_{\alpha\beta}^{(1)}=2S\left(\frac{1}{4}q^2\right)f_{\alpha\beta}{}^N(q_\perp,q_\parallel). \tag{16}$$

In the ratio of the right-hand sides of Eqs. (15) and (16) for $q^2\to0$ the inelastic amplitude $f_{\alpha\beta}^N$ cancels, and therefore the results can be related to the same ratio for the elastic scattering amplitude[9]:

$$\left.\frac{f_{\alpha\alpha\beta}^{(2)}+f_{\alpha\beta\beta}^{(2)}}{f_{\alpha\beta}^{(1)}}\right|_{q^2\to0}=-\delta r_{\text{el}}. \tag{17}$$

Here $r_{\text{el}}=f_{\alpha\alpha\alpha}^{(2)}/f_{\alpha\alpha}^{(1)}$ is the relative value of the Glauber correction to the total cross section in the deuteron.

The dependence $f_{\alpha\alpha}^N(q^2)$ we shall write in the form

$$f_{\alpha\alpha}{}^N(q^2)=f_{\alpha\alpha}{}^N(0)\exp(-R_N{}^2q^2). \tag{18}$$

Here $2R_N^2$ is the slope of the diffraction peak in elastic scattering by a nucleon. Since in the reaction $pp\to pX$ the inelastic vertex does not contain a dependence on q^2, we have

$$f_{\alpha\beta}{}^N(q^2)=f_{\alpha\beta}{}^N(0)\exp\{-{}^1/{}_2R_N{}^2q^2\}. \tag{19}$$

When this is taken into account, the dependence of expression (17) on q^2 has the form

$$\frac{f_{\alpha\alpha\beta}^{(2)}+f_{\alpha\beta\beta}^{(2)}}{f_{\alpha\beta}^{(1)}}=-\delta r_{el}\exp\left\{\frac{1}{8}R_N{}^2(q^2-q_\parallel{}^2)\right\}F(q_\parallel{}^2), \tag{20}$$

where

$$F(q_\parallel{}^2)=\frac{\int d^2k_\perp S({}^1/{}_2q_\parallel{}^2+k_\perp{}^2)}{\int d^2k_\perp S(k_\perp{}^2)}. \tag{21}$$

It should be noted that the factor δ may depend on $q_\parallel$ logarithmically, since the number of created particles increases with M_X^2. However, we shall neglect this weak dependence in comparison with the exponential.

Calculation of a correction of the inelastic type $f_{\alpha\gamma\beta}^{(2)}$ is a very difficult job. We know nothing about the amplitude $f_{\gamma\beta}^N$ for diffraction of the beam of particles into a beam. We can nevertheless evaluate the ratio $f_{\alpha\beta}^{(2)}/f_{\alpha\beta}^{(1)}$, by means of the two-component parton model developed in Section 3.

From the relations (8) and (4) we have

$$f_{\alpha\gamma\beta}^{(2)}(b)=c_{\alpha0}c_{0\beta}{}^*(F-f_0)^2(1-|c_{\alpha0}|^2-|c_{\beta0}|^2). \tag{22}$$

Here summation over $\gamma\neq\alpha,\beta$ is implied. The relation is written in the representation of the impact parameter b. We obtain[1] from Eqs. (22) and (8)

$$\left.\frac{f_{\alpha\beta}^{(2)}}{f_{\alpha\beta}^{(1)}}\right|_{q^2\to0}=\frac{\int(F^2-f_0{}^2)d^2b}{\int(F-f_0)d^2b}. \tag{23}$$

The similar relation in elastic scattering after summation of the elastic and inelastic Glauber corrections has the form (see Footnote 1)

$$\left.\frac{f_{\alpha\alpha}^{(2)}}{f_{\alpha\alpha}^{(1)}}\right|_{q^2=0}=\frac{\int[F^2-|c_{\alpha0}|^2(F^2-f_0{}^2)]d^2b}{\int[F-|c_{\alpha0}|^2(F-f_0)]d^2b}. \tag{24}$$

It is evident from comparison of Eqs. (22) and (23) that if the passive amplitude f_0 can be set equal to zero, then

$$\varkappa=(f_{\alpha\beta}^{(2)}/f_{\alpha\beta}^{(1)})/(f_{\alpha\alpha}^{(2)}/f_{\alpha\alpha}^{(1)})=1.$$

The same conclusion regarding the equality of the relative corrections for rescattering in elastic and inelastic diffraction was drawn previously in Ref. 9 on the basis of the parton model with one component $k=1$. In the two-component model this result is valid only for $f_0=0$. Inclusion of other components will lead to violation of this equality. In addition, it was found in Ref. 9 from the condition $\varkappa=1$ that the term $f^{(2)}_{\alpha\gamma\beta}$ has an anomalous sign. In the multicomponent model this relation does not exist. We note, of course, that in the one-component variant of the eigenstate model, inelastic diffraction is completely absent.

Knowing the value of $\varkappa$, we can find the ratio $\lambda/r_{el} = f^{(2)}_{\alpha\gamma\beta}/f^{(1)}_{\alpha\beta}|_{q^2\to 0}$ from

$$\delta-\lambda=\frac{\varkappa}{r_{el}}\frac{f^{(3)}_{\alpha\alpha}}{f^{(1)}_{\alpha\alpha}}\Big|_{q^2=0}. \quad (25)$$

The dependence of $f^{(2)}_{\alpha\gamma\beta}$ on q^2 and $q^2_\parallel$ can be found from Eqs. (15) and (19). In (15) we shall take into account only the exponential dependence on $q^2_\parallel$, neglecting the unknown power-law dependence on $q_\parallel$. Using in addition Eqs. (20) and (16), we eventually obtain

$$\frac{f^{(2)}_{\alpha\beta}}{f^{(1)}_{\alpha\beta}}(x,q^2)=\frac{r_{el}}{S(^1/_4q^2)}\Big[\delta F(q_\parallel^2)\exp\Big\{\frac{1}{8}R_N^2(q^2-q_\parallel^2)\Big\} -\lambda\exp\Big\{\frac{1}{4}R_N^2q^2\Big\}\Big]. \quad (26)$$

Here all of the parameters except $\varkappa$ and δ are known, and therefore we can attempt by means of Eq. (12) to describe the data of Fig. 2, setting $\varkappa=1$ in accordance with Eqs. (23) and (24) and considering δ a free parameter. The best result of such a description with $\delta = 2.34\pm0.14$ is shown in Fig. 2 by the dashed curve. Here we have used the following values of the fixed parameters in Eq. (26): $r_{el}=0.045$, $r_{el}(\delta-\lambda)/\varkappa = 0.057$,[10] $R^2_N=5$ $(\mathrm{GeV}/c)^{-2}$; the form factor $S(q^2)$ was taken from Ref. 11.

In order to approve the agreement with the experimental data one can abandon the equality $\varkappa=1$, since it was obtained in the approximate two-component model. In this case a second free parameter appears. We note that the quantity $\varkappa$ does not affect the value of $1-x$ at which $R(x)$ changes sign, but has its effect mainly in the value of $R(x)$ at small values of $1-x$. The result of the description with two free parameters is shown in Fig. 2 by the solid curve. The parameters found are as follows:

$$\delta=4.46\pm0.12,\ \varkappa=1.56\pm0.037.$$

In both variants the experimental data[7] clearly confirm the phenomenon of antiscreening in elastic diffraction.[2)]

5. IS IT POSSIBLE TO DETERMINE THE CROSS SECTION FOR ABSORPTION OF HADRONS CREATED IN DIFFRACTION PROCESSES IN NUCLEI?

One of the basic results obtained during ten years of study of the coherent production of particles in nuclei has been the determination of the cross sections for interaction of unstable hadronic systems with a nucleon. In a theoretical analysis of the data, the cross section for the dissociation $\alpha\to\beta$ in a nucleus is usually calculated in an approximation of the Glauber type, where β is created in one of the nucleons and elastic rescatterings of α and β inside the nucleus are taken into account[13] (see Fig. 3a). The cross sections found

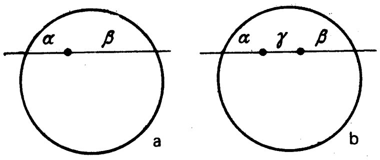

FIG. 3. Various contributions to the amplitude for diffraction dissociation in a nucleus.

in this way for the βN interaction have turned out to be astonishingly small.[14]

The principle correction to calculations of this type is due to the process shown schematically in Fig. 3b. The antiscreening sign of this correction is felt in that failure to take it into account leads to a decrease of the cross section $\sigma^{\beta N}_{tot}$. Rough estimates show that the size of this effect is of the order of 100%.

In order to be convinced of this, let us turn to the process of diffraction in the deuteron, discussed above. Best agreement with the experimental data was obtained for $\delta=4.46$, i.e., $\sigma^{\beta N}_{tot}/\sigma^{\alpha N}_{tot}=3.46$. The value of the other parameter found in this case, $\varkappa$, gives $\delta-\lambda=2$. It can be seen from this that if we neglect the contribution of $f^{(2)}_{\alpha\gamma\beta}$ in the region of small values of $1-x$ (i.e., $\lambda=0$), then the parameter δ turns out to be $\delta=2$, i.e., $\sigma^{\beta N}_{tot}/\sigma^{\alpha N}_{tot}=1$ (compare with Ref. 7), which is substantially less than the true value 3.46.

Thus, analysis of the data without taking into account antiscreening corrections leads to meaningless results. Miettinen and Pumplin[15] in a recent article reaches the same conclusion. They used a parton model[5] similar to ours. However, these authors concluded that the reason that the cross sections $\sigma^{\beta N}_{tot}$ extracted from the data turn out to be underestimated lies in the incorrect space-time picture of the multiple-scattering model. Actually the source of error is in failure to take into account antiscreening corrections.

Unfortunately, explicit calculation of all antiscreening corrections is a very complicated problem. Even in the case of scattering by the deuteron the result obtained, $\sigma^{\beta N}_{tot}/\sigma^{\alpha N}_{tot}=3.46$, must be taken only as an estimate, as the result of the significant theoretical uncertainties in the calculation. Thus, the possibility of determination of the cross sections $\sigma^{\beta N}_{tot}$ from data of this type is as yet doubtful. We note also that at the qualitative level it is possible to explain certain strange results obtained previously. Thus, in the dissociation reaction $\pi\to 3\pi$ the strong dependence of the cross section $\sigma^{\beta N}_{tot}$ on the spin and parity of the 3π system[14] is apparently a simple reflection of the dependence of the antiscreening contribution on the mass of the 3π. This dependence can be extremely strong, since the energies at which the experiments were carried out are low, so that the nuclear form factor enhances the relative contribution of the antiscreening corrections. As an illustration we can again resort to the example of the deuteron. If we determine $(\sigma^{\beta N}_{tot})_{eff}$ from the data of Ref. 7, neglecting antiscreening, then, as can be seen from Fig. 2, $(\sigma^{\beta N}_{tot})_{eff}$ falls off in the region $1-x\approx 0.1-0.2$, and at $1-x=0.2$ it will be $(\sigma^{\beta N}_{tot})_{eff}=-\sigma^{NN}_{tot}$.

6. CONCLUSION

Let us enumerate briefly the principal results of this work.

1. It is shown that the eigenstate model and the multiple-scattering model are equivalent, and therefore the latter correctly reflects the space-time picture of the interaction.

2. In the two-component approximation of the quark-parton model it is found that all inelastic diffraction amplitudes have a negative imaginary part, in contrast to the elastic amplitude.

3. For this reason a number of Feynman diagrams in diffraction processes in nuclei have an anomalous sign. Thus, the contribution of double inelastic diffraction has an antiscreening nature.

4. This conclusion is confirmed by analysis of the experimental data[7] of the reaction $pd \to dX$.

5. The procedure for determination of the cross sections for absorption in the nucleus of hadronic systems created in diffraction dissociation must take into account antiscreening corrections, or else the result will turn out to be highly underestimated.

In addition, several further remarks can be made.

a) All inelastic corrections of higher order to the amplitude for inelastic diffraction by a nucleus (after summation over all elastic rescatterings) have the same antiscreening sign.

b) The negative sign of the inelastic diffraction amplitude is felt also in elastic scattering: all inelastic corrections to the elastic hadron-nucleus amplitude have the same sign—negative.

c) It follows from this that in determination of the cross section for absorption of vector mesons created in photoproduction in a nucleus, failure to take into account inelastic corrections will lead to exaggeration of the corss section. It is true that the error in this case is not large, as in diffraction dissociation.

d) In inclusive production of particles in nuclei the absorption of the created particles is calculated without taking into account inelastic corrections. This leads to the result that the absorption cross sections found from these data turn out to be underestimated, which partially imitates passivity of the created particles.

e) Structures of the diffraction type (minima, breaks) in the differential cross section for inelastic diffraction should disappear with increase of the effective mass of the system of created particles. At the same time the slope of the differential cross section should decrease. This is due to the antiscreening nature of the inelastic corrections.

f) If the A-dependence of the cross section for diffraction dissociation in a nucleus is represented in the form A^{α}, the exponent α should be a rising function of the effective mass of the system of created particles.

We are happy to express our gratitude to E. M. Levin and M. G. Ryskin for helpful discussions.

[1)] In reality the integration in Eqs. (23) and (24) is more complicated. The integrand depends on the nucleon coordinates, over which it is necessary to carry out an integration with allowance for the density distribtuion in the nucleon. However, these complications do not affect the result of interest here.

[2)] The only data existing in the literature at ISR energies[12] in addition to those of Ref. 11 do not permit definite conclusions to be drawn, as a result of the large experimental errors.

[1] E. L. Feinberg and I. Ya. Pomeranchuk, Nuovo Cimento Suppl. **111**, 652 (1956). I. Ya. Pomeranchuk, Sobranie nauchnykh trudov (Collected Scientific Works), Vol. 3, Nauka, 1972, p. 181.

[2] M. L. Good and W. D. Walker, Phys. Rev. **120**, 1857 (1960).

[3] B. Z. Kopeliovich and L. I. Lapidus, Pis'ma Zh. Eksp. Teor. Fiz. **28**, 664 (1978) [JETP Lett. **28**, 614 (1978)].

[4] B. Z. Kopeliovich and L. I. Lapidus, Trudy V Mezhdunarodnogo seminara po mnozhestvennomu rozhdeniyu adronov pri vysokikh énergiyakh (Proceedings of the Fifth Intern. Seminar on Multiple production of Hadrons at High Energies), Dubna, 1978.

[5] H. I. Miettinen and J. Pumplin, FERMILAB-Pub-78/21-THY, 1978.

[6] V. N. Gribov, Zh. Eksp. Teor. Fiz. **56**, 892 (1969); Zh. Eksp. Teor. Fiz. **57**, 1306 (1969) [Sov. Phys. JETP **29**, 483 (1969); Sov. Phys. JETP **30**, 709 (1970)].

[7] Yu. Akimov *et al.*, Phys. Rev. Lett. **39**, 1432 (1977).

[8] Yu. M. Kazarinov, B. Z. Kopeliovich, L. I. Lapidus, and I. K. Potashnikova, Zh. Eksp. Teor. Fiz. **70**, 1152 (1976) [Sov. Phys. JETP **43**, 598 (1976)].

[9] E. M. Levin, M. G. Ryskin, N. I. Strikman, and G. G. Takhtamyshev, Nucl. Phys. **B124**, 539 (1977).

[10] P. V. R. Murthy *et al.*, Nucl. Phys. **B92**, 269 (1975).

[11] V. Franco and G. K. Varma, Phys. Rev. **C12**, 225 (1975).

[12] J. C. M. Armitage *et al.*, CERN Preprint, 1977.

[13] A. V. Tarasov, Fiz. Elem. Chastits At. Yadra **7**, 771 (1976) [Sov. J. Part. Nucl. **7**, 306 (1976)].

[14] L. Rosen, in: High Energy and Nuclear Structure, eds. D. E. Nagle *et al.*, American Institute of Physics, Conference Proceedings No. 26, N. Y., 1975.

[15] H. I. Miettinen and J. Pumplin, FERMILAB-Pub-78/62-THY, 1978.

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