CERN-TH.4974/88

NUCLEAR EFFECTS IN J/ψ SUPPRESSION

A.Capella ¹⁾, J.A. Casado ^{1,2)}, C. Pajares ²⁾, A.V. Ramallo ³⁾ and J. Tran Thanh Van ¹⁾

CERN - Geneva

Abstract

We compute the effect on the J/ψ production in nucleus-nucleus collisions of the absorption of the J/ψ inside the colliding nuclei. Using a value of the absorptive J/ψ -nucleon cross section which reproduces the A -dependence of the J/ψ cross section in hadron-nucleus collisions, we obtain much less suppression than that measured by the NA38 collaboration. The effect due to a strongly absorbed ($A^{0.7}$) component is also discussed. In order to explain the NA38 results one needs a very large contribution (50%) of the latter component.

¹⁾ Laboratoire de Physique Théorique et Hautes Energies, Université de Paris-Sud, Orsay, France

²⁾ Departamento de Partículas Elementales, Universidade de Santiago de Compostela, Spain

³⁾ CERN, Geneva

1 – INTRODUCTION. The NA38 Collaboration has obtained preliminary results[1] showing that the ratio $R = \sigma_{J/\psi} / \sigma_{DY}$ in Oxygen – Uranium collisions decreases substantially when the transverse energy E_T of the collision increases. This phenomenon had been predicted in Ref. [2] as a consequence of the formation at large E_T (i.e. for central collisions) of a quark – gluon plasma – the suppression of the J/ψ signal with respect to the Drell – Yan continuum being a consequence of color screening.

The experimental observation of such an effect, shortly after its theoretical prediction, is an extremely great achievement of the NA38 Collaboration, and a very interesting result in itself. However, in view of its importance as a possible signal of formation of a quark – gluon plasma, one has to find out whether or not it can be understood with more conventional physics. This is the purpose of this letter.

Let us start by recalling the differences in the A – dependence of the J/ψ and Drell – Yan continuum cross sections that have been observed in hadron – nucleus collisions. It has been experimentally established[3,4,5] that the $pA \rightarrow J/\psi$ inclusive cross section grows with A as A^α with $\alpha < 1$. The value of α depends strongly on X_F . It is about 0.97 at $X_F \sim 0$ and decreases towards 0.7 when X_F increases towards 1. For the Drell – Yan continuum no significant departure from unity in the value of α has been reported[3] at least for masses of the pair above the J/ψ mass. This different behaviour of the J/ψ and Drell – Yan cross sections is an obvious source of J/ψ suppression because it implies that the number of J/ψ events decreases with respect to the number of continuum dimuons as $A^{\alpha - 1}$ when the nucleon size is increased. Moreover, increasing E_T , i.e. the centrality of the collision, amounts in fact to increasing the effective nuclear size.

In order to estimate the effect of these different behaviours in $A - B$ collisions, one must understand first where this difference comes from. Here we shall adopt the following picture, that has been suggested before by many authors[3,6,7]. Due to the large mass of the charm quark, the production of a $c - \bar{c}$ pair is almost point – like, i.e. the $c - \bar{c}$ pair is produced almost at the interaction point. Therefore it can be subsequently absorbed within the nucleus via inelastic collisions with the nucleons. This

will prevent the J/ψ to appear in the final state and will result in open charm production. The Drell - Yan continuum dimuons, on the contrary, are produced electromagnetically and cannot be absorbed. It is well known (see below) that it is possible in this way to reproduce, in the framework of the Glauber model, the observed difference in the behaviour of the J/ψ and continuum cross sections at small X_F . On the other hand the behaviour in $A^{0.7}$ observed in J/ψ production at large X_F can, of course, not be explained in this way and can only result from strong screening effects corresponding to a typical hadronic cross section (i.e. of $20 \div 30$ mb).

In the next section we shall concentrate on the effect coming from the J/ψ interaction within the nucleus. The effect due to the strongly absorbed component will be discussed in section 3.

2 - INTRA - NUCLEAR ABSORPTION OF THE J/ψ . Let us define by σ the NN non - diffractive inelastic cross section, σ_ψ the cross section for J/ψ production in NN collisions (which experimentally is of the order of few nanobarns [3]) and $\sigma_{\psi N}^{\text{abs}}$ the absorptive ψ - nucleon cross section (corresponding to final states without the J/ψ). Let us consider first the hadron - nucleus case. We want to calculate, in the framework of the probabilistic Glauber model, the probability of the events in which a J/ψ is produced at a point of coordinates $(\vec{b}, z)$ inside the nucleus and it is not destroyed during its subsequent propagation through the nuclear matter. After integrating over the longitudinal coordinate z we obtain the "survival" probability as a function of the impact parameter b :

$$\begin{aligned} \sigma_\psi^s(b) &= \int_{-\infty}^{+\infty} dz \sigma_\psi \rho_A(\vec{b}, z) \left[1 - \sigma_{\psi N}^{\text{abs}} \int_z^{+\infty} \rho_A(\vec{b}, z_1) dz_1 \right]^A = \\ &= \frac{\sigma_\psi}{\sigma_{\psi N}^{\text{abs}} (A+1)} \left[1 - \left[1 - \sigma_{\psi N}^{\text{abs}} T_A(b) \right]^{A+1} \right] \end{aligned} \quad (1)$$

In equation (1) $T_A(b)$ is the profile function of the nucleus, obtained by integrating the nuclear density $\rho_A(\vec{b}, z)$ over the z coordinate: $T_A(b) = \int_{-\infty}^{+\infty} \rho_A(\vec{b}, z) dz$. In this paper we shall use a standard Saxon - Wood parametrization for the nuclear densities. Obviously the probability of "non survival" of a J/ψ is :

$$\sigma_\psi^{\text{ns}}(b) = \sigma_\psi T_A(b) - \sigma_\psi^s(b) \quad (2)$$

Let us calculate now the probability $\sigma_{n,i,k}^{pA \rightarrow \psi}(b)$ corresponding to events in which n pN collisions have taken place, at least a J/ψ is produced in i of these n collisions and only k of them survive the interactions inside the nucleus — being the remaining $i-k$ ones destroyed via inelastic collisions. One has:

$$\sigma_{n,i,k}^{pA \rightarrow \psi}(b) = \binom{A}{n} \binom{n}{i} \binom{i}{k} [\sigma_{\psi}^s(b)]^k [\sigma_{\psi}^{ns}(b)]^{i-k} [(\sigma - \sigma_{\psi})T_A(b)]^{n-i} [1 - \sigma T_A(b)]^{A-n} \quad (3)$$

In order to obtain the cross section for J/ψ production as a function of the number n of collisions, one has to sum in k from $k=1$ to i (at least one J/ψ has to survive) and in i from 1 to n (at least a J/ψ has to be produced). Linearizing in the small quantity σ_{ψ} and integrating over b , one gets:

$$\sigma_n^{pA \rightarrow \psi} = n \binom{A}{n} \int d^2b \sigma_{\psi}^s(b) (\sigma T_A(b))^{n-1} (1 - \sigma T_A(b))^{A-n} \quad (4)$$

Summing over n and taking into account equation(1), we arrive at the simple expression:

$$\sigma^{pA \rightarrow \psi} = \frac{A \sigma_{\psi}}{\sigma_{a b s}^{\psi N (A+1)}} \int d^2b \left[1 - (1 - \sigma_{a b s}^{\psi N} T_A(b))^{A+1} \right] \quad (5)$$

If we parametrize the cross section $\sigma_{pA \rightarrow \psi}$ as $\sigma_{\psi} A^{\alpha}$, the value of the exponent α is directly related to the value of the cross section $\sigma_{abs}^{\psi N}$. The greater $\sigma_{abs}^{\psi N}$ we take, the lower α we have. For example if we take $\sigma_{abs}^{\psi N} = 4\text{mb}$, we obtain $\alpha \approx 0.95$, which is very close to the experimental value.

Let us try to generalize the above formalism to $A-B$ nucleus-nucleus collisions. In the same way as we did in the pA case we have to calculate first the probability of producing a J/ψ in an individual NN collision and that it will not be destroyed as a consequence of inelastic interactions within nucleus A or B . So, consider a collision between two nucleons (one of each nucleus) which takes place in an event having impact parameter b . Suppose that the nucleon of A that we are considering has a transverse coordinate $\vec{s}$ with respect to the center of nucleus A . Then obviously the nucleon of B has a transverse coordinate equal to $\vec{b} - \vec{s}$ with respect to the center of B . Repeating for each nucleus the same steps which led us to the last expression in equation (1) and integrating over s , we obtain the survival probability at impact parameter b :

$$\sigma_{\psi}^s(b) = \frac{\sigma_{\psi}}{(\sigma_{a b_s}^{\psi N})^2 (A+1)(B+1)} \int d^2s \left[1 - (1 - \sigma_{a b_s}^{\psi N} T_A(\vec{s}))^{A+1} \right] \times \\ \times \left[1 - (1 - \sigma_{a b_s}^{\psi N} T_B(\vec{b} - \vec{s}))^{B+1} \right] \quad (6)$$

In the same way as we did in the proton-nucleus case, it is easy to check that the "non survival" probability is: $\sigma_{\psi}^{ns}(b) = \sigma_{\psi} T_{AB}(b) - \sigma_{\psi}^s(b)$, where $T_{AB}(b)$ is the convolution of the profiles of the colliding nuclei: $T_{AB}(b) = \int d^2s T_A(\vec{s}) T_B(\vec{b} - \vec{s})$. In complete analogy with the hadron-nucleus case and applying the methods developed in Ref. [8], it is possible to obtain the J/ψ production cross sections $\sigma^{AB \rightarrow \psi}_{n_A n_B n}$ for fixed numbers n_A and n_B of participants in A and B and a fixed number n of inelastic NN collisions. As a function of the impact parameter the corresponding expression is:

$$\sigma_{n_A, n_B, n}^{AB \rightarrow \psi}(b) = \sigma_{\psi}^s(b) (\sigma T_{AB}(b))^{n-1} (1 - \sigma T_{AB}(b))^{AB-n} \times \\ \times n \binom{A}{n_A} \binom{B}{n_B} \sum_{i=1}^{n_B} \sum_{j=1}^{n_A} \binom{n_B}{i} \binom{n_A}{j} \binom{i+j}{n} (-)^{n_A+n_B-i-j} \quad (7)$$

where we have already linearized in the small quantity $\sigma_{\psi}^s(b)$. By summing over n, n_B and n_A we obtain the following equations:

$$\sigma_{n_A}^{AB \rightarrow \psi}(b) \equiv \sum_{n_B=1}^B \sum_{n=1}^{AB} \sigma_{n_A, n_B, n}^{AB \rightarrow \psi}(b) = \sigma_{\psi}^s(b) n_A B \binom{A}{n_A} [1 - \sigma T_{AB}(b)]^{B(A-n_A)} \times \\ \times [1 - (1 - \sigma T_{AB}(b))^B]^{n_A-1} \quad (8)$$

$$\sigma^{AB \rightarrow \psi} \equiv \int d^2b \sum_{n_A=1}^A \sigma_{n_A}^{AB \rightarrow \psi}(b) = \int d^2b AB \sigma_{\psi}^s(b) = \\ = \frac{AB \sigma_{\psi}}{(\sigma_{a b_s}^{\psi N})^2 (A+1)(B+1)} \int d^2b d^2s \left\{ [1 - (1 - \sigma_{a b_s}^{\psi N} T_A(\vec{s}))^{A+1}] [1 - (1 - \sigma_{a b_s}^{\psi N} T_B(\vec{b} - \vec{s}))^{B+1}] \right\} \quad (9)$$

where in equation(9) we have already integrated in b . In our numerical evaluation of equation(9) (see below) we have checked that $\sigma^{AB \rightarrow \psi}$ can be approximately parametrized as $(AB)^{\alpha}$ - α being the same exponent as in proton-nucleus collisions for the same value of $\sigma_{\psi}^{\psi N}_{abs}$.

Let us apply now these equations to the calculation of the J/ψ suppression. Let us first note that the cross section for Drell – Yan production of dimuons can be obtained from our previous equations by putting $\sigma^{\psi N}_{abs}=0$ and changing σ_ψ by σ_{DY} (the Drell – Yan cross section in NN collisions). We are specially interested in calculating the ratio of the two cross sections as a function of the centrality of the collision. In hadron – nucleus collisions a good measure of the centrality is the number n of NN collisions. In any model of multiparticle production, such as for example the Dual Parton Model[9](DPM), this number n is related to the transverse energy E_T of the collision. Using the above – mentioned prescriptions for computing the Drell – Yan cross section and equation (4), it is very easy to obtain the expression for the ratio $R_n = \sigma_n^{pA \rightarrow \psi} / \sigma_n^{pA \rightarrow \mu^+ \mu^-}$

$$R_n = \frac{\sigma_\psi}{\sigma_{DY}} \frac{\int d^2b [1 - (1 - \sigma_{abs}^{\psi N} T_A(b))^{A+1}] (\sigma T_A(b))^{n-1} (1 - \sigma T_A(b))^{A-n}}{\sigma_{abs}^{\psi N} (A+1) \int d^2b T_A(b) (\sigma T_A(b))^{n-1} (1 - \sigma T_A(b))^{A-n}} \quad (10)$$

The values of R_n for proton – Uranium collisions and $\sigma^{\psi N}_{abs}=4\text{mb}$ are given in table 1. They are expressed in units of σ_ψ/σ_{DY} (which is roughly equal to 10). We see from these values that the main variation of n occurs at small values of n (and therefore at low values of the transverse energy).

In $A - B$ collisions with $A \ll B$, a good parameter to measure the centrality of the collision is the number n_A of participant nucleons of the lighter nucleus A . Proceeding as before, we can write the suppression ratio as a function of n_A :

$$R_{n_A} = \frac{\int d^2b \sigma_\psi^s(b) (1 - \sigma T_{AB}(b))^{B(A-n_A)} [1 - (1 - \sigma T_{AB}(b))^B]^{n_A-1}}{\sigma_{DY} \int d^2b T_{AB}(b) (1 - \sigma T_{AB}(b))^{B(A-n_A)} [1 - (1 - \sigma T_{AB}(b))^B]^{n_A-1}} \quad (11)$$

where $\sigma_\psi^s(b)$ is given by equation (6). In table 2 we have written the values of R_{n_A} in Oxygen – Uranium and Sulphur – Uranium collisions for a value of $\sigma^{\psi N}_{abs}=4\text{mb}$ [10]. The value of α corresponding to this input is 0.95 which is compatible with the experimental value. For example the NA3 collaboration[3] has found for $p - \text{Pt}$ collisions at 200 GeV $\alpha = 0.94 \pm 0.03$. As in the proton – nucleus case the results are given in units of σ_ψ/σ_{DY} .

In order to make a comparison of our results with the NA38 preliminary data we have to determine the average number of participant nucleons corresponding to the regions of E_T considered in the NA38 experiment. At present R has been measured in four intervals of E_T : $E_T < 28$ GeV, $28 \text{ GeV} < E_T < 40$ GeV, $40 \text{ GeV} < E_T < 50$ GeV and $E_T > 50$ GeV. It is estimated that the NA38 calorimeter measures all the electromagnetic energy (i.e. photons) and about 15% of the hadronic energy. Thus the total transverse energy (neutrals plus charged) can be approximately obtained by multiplying the above experimental values of E_T by a factor of two. We have computed in the DPM the value of the total transverse energy corresponding to $n_A = 16$ and we have obtained a value around 100 GeV. This shows that the large E_T interval ($E_T > 50$ GeV) corresponds to central collisions in which all the sixteen nucleons of the Oxygen projectile are involved. A similar calculation shows that the low- E_T interval ($E_T < 28$ GeV) corresponds to events in which ten nucleons of the Oxygen participate. The experimental values for the J/ψ /Drell-Yan ratio for the two extreme intervals are 9.3 ± 0.6 ($E_T < 28$ GeV) and 5.9 ± 0.4 ($E_T > 50$ GeV). What is physically relevant is the ratio between these two ratios, which is 0.63. So this means that a suppression of 37% has been observed in this E_T range. Let us now look at our theoretical results and let us try to compare them with the NA38 measurements. From the numbers given in table 2 we immediately obtain that the suppression ratio is 0.85. Thus this mechanism accounts for a suppression of 15% [11]. From table 2 we also see that the suppression in S-U collisions, say between $n_A = 20$ and $n_A = 32$, is approximately the same as in O-U collisions. Taking $\sigma_{\psi N}^{\text{abs}} = 6 \text{ mb}$, corresponding to $\alpha = 0.92$, this suppression is only of 20%.

In order to see whether or not higher suppressions can be achieved with our mechanism we have calculated the J/ψ /Drell-Yan ratio as a function of n_B for $n_A = 16$ in O-U collisions. We have checked that the value of R for $n_A = 16$ is almost the smallest value one can obtain in O-U collisions. Indeed, by increasing the value of n_B beyond its average value (which is 65) there is a saturation effect — the ratio R reaching quickly a constant value. So we are forced to conclude that this mechanism cannot explain all the observed J/ψ suppression.

3 — THE STRONGLY ABSORBED COMPONENT. As already mentioned in the Introduction, a substantial fraction of the $pA \rightarrow J/\psi$ inclusive cross section is strongly absorbed and behaves as A^α with $\alpha \sim 0.7$. In Ref. [3] it has been found that, in the case of an incoming proton, a fraction of the

cross section of 0.29 ± 0.06 behaves in this way. Such a contribution is called "diffractive" or "soft" in Ref. [3] and it has been found to be important at large X_F and low p_T . According to Ref. [5], this component seems to be even larger since it is the only one they can observe with their acceptances. The observed behaviour of α as a function of X_F can in fact be qualitatively understood without introducing a separate mechanism. Indeed, strong screening corrections are present both in soft and in hard production processes. The fact that many hard cross sections behave as A^1 is due to the cancellation in such cases of the screening corrections[12]. More precisely, the screening corrections due to the elastic and inelastic rescattering cancel with one another. This phenomenon (called the AGK cancellation[13]) occurs for all inclusive cross sections (soft and hard) near $X_F \sim 0$ as well as for total cross sections corresponding to events obeying some well defined criterion[14]. The observed decrease of α with increasing X_F may be due to the fact that ,when X_F increases, the screening due to the inelastic rescattering becomes less and less important (due to energy momentum conservation constraints) and the AGK cancellation is violated. We should stress, however, that we do not know of any quantitative explanation of the X_F dependence of α in J/ψ production. In the case of Drell - Yan production it is not understood (even in a qualitative way) why the projectile screening does not change the value of α at large X_F . Although we do not understand this last experimental result, we shall use it from now on.

In the following we shall take a very crude approach. We shall evaluate the effect on the J/ψ suppression resulting from a strongly absorbed component (behaving as $A^{0.7}$). By combining the results obtained in this case with those of the previous section we shall determine the relative contribution which is needed in order to reproduce the results of the NA38 collaboration.

Let us assume that (due to energy - momentum conservation constraints) the J/ψ can only be produced in one of the NN collisions of a given NB subcollision. The corresponding survival probability is given by:

$$\begin{aligned} \sigma_{NB}^s(b) &= \sum_{n=1}^B \binom{B}{n} \sigma_{\psi}^s(b) \left[(\sigma - \sigma_{\psi}) T_{AB}(b) \right]^{n-1} \cdot \left[1 - \sigma T_{AB}(b) \right]^{B-1} \approx \\ &\approx \frac{\sigma_{\psi}^s(b)}{\sigma T_{AB}(b)} \left[1 - (1 - \sigma T_{AB}(b))^B \right] \end{aligned} \quad (12)$$

where $\sigma_{\psi}^s(b)$ is given by equation (6) and in the last step we have already linearized in σ_{ψ} . In the ha-

dron – nucleus case it is easy to check that equation (12) (after integrating in b) gives a cross – section that grows as $A^{0.7}$, as desired. In order to obtain the cross sections $\sigma_{n_A}^{AB \rightarrow \psi}$ and the suppression ratio R_{n_A} for this case one has to substitute in equations(8) and (11) $B\sigma_\psi(b)$ by $\sigma_{NB}^s(b)$. The numerical results are given in table 3 for O – U collisions (we use $\sigma_{abs}^{\psi N} = 4$ mb and $\sigma = 30$ mb). Notice that now the suppression between $n_A = 10$ and $n_A = 16$ is very important. Combining these results with those given in table 2 we can compute the J/ψ suppression between $n_A = 10$ and $n_A = 16$ for different values of the relative contribution $r = \sigma_{n_A,sa} / (\sigma_{n_A,sa} + \sigma_{n_A,wa})$ where $\sigma_{n_A,sa}$ and $\sigma_{n_A,wa}$ are the contributions to $\sigma_{n_A}^{AB \rightarrow \psi}$ of the strongly and weakly absorbed components respectively. In order to obtain the suppression observed by the NA38 collaboration we need that $r = 0.5$, whereas for $r = 0.3$ (which is the value obtained in Ref. [3]) we have a suppression of 25%, which is much lower than the one observed by the NA38 collaboration.

4 – DISCUSSION AND CONCLUDING REMARKS. We have evaluated the nuclear effects in the J/ψ suppression resulting from two different components : a weakly absorbed component (resulting from the intra – nuclear interaction of the J/ψ) behaving as A^α with $\alpha \sim 0.95 \div 0.97$ and a strongly absorbed one behaving as $A^{0.7}$ (resulting from strong screening of the projectile with a typical nucleon – nucleon cross section). This separation, motivated by the results of Ref. [3], does not imply that two different mechanisms are present in the J/ψ production. For us it is just a crude but convenient way of describing the fact that strong screening corrections cancel each other at $X_F \sim 0$ and become increasingly important at large X_F . In order to reproduce the NA38 results we need a very large contribution (50%) of the second component. Although the results of Ref. [5] seem to favor such a large contribution, it seems unlikely that it can explain the results of the NA38 collaboration. Indeed it has been shown in Ref. [3] that the strongly absorbed component is important at large X_F – and the results of the NA38 collaboration correspond to rather small values of X_F . A firmer conclusion would require a precise knowledge (both experimental and theoretical) of the X_F distribution of the J/ψ and continuum event samples. It should also be checked that the observed suppression is also present when selecting events in low X_F interval.

Acknowledgments

It is a pleasure to thank C. Gerschel, L. Kluberg, J. Kwiecinski, C. Lourenço, R. Salmeron and P. Sonderegger for very useful discussions. We specially thank J. Hüfner for many useful discussions and for pointing out to us an error at an early stage of this work.

Table 1: J/ψ suppression in $p-U$ interactions as a function of the number n of NN collisions.

n	R_n	n	R_n
1	0.916	6	0.731
2	0.845	7	0.721
3	0.796	8	0.714
4	0.765	9	0.708
5	0.745	10	0.701

Table 2: J/ψ suppression in $O-U$ and $S-U$ as a function of n_A

n_A	$R(O-U)$	n_A	$R(S-U)$
1	0.850	2	0.856
2	0.836	4	0.828
3	0.812	6	0.808
4	0.797	8	0.793
5	0.786	10	0.779
6	0.776	12	0.766
7	0.766	14	0.755
8	0.756	16	0.744
9	0.747	18	0.733
10	0.737	20	0.723
11	0.727	22	0.713
12	0.715	24	0.702
13	0.703	26	0.690
14	0.686	28	0.676
15	0.660	30	0.654
16	0.630	32	0.617

Table 3: *J/ψ suppression in O-U collisions as a function of n_A for the strongly absorbed component.*

n_A	R	n_A	R
1	0.824	9	0.503
2	0.781	10	0.464
3	0.731	11	0.422
4	0.690	12	0.379
5	0.653	13	0.331
6	0.616	14	0.275
7	0.579	15	0.204
8	0.541	16	0.141

References

- [1] M.C. Abreu et al. (NA38 collaboration), presented by A. Bussiere at Quark Matter 87 Conference, Nordkirchen, F.R. Germany (24-27 August 1987). Proceedings ed. H.Satz and H.J. Specht, to be published in Z. Phys. C..
- [2] T. Matsui and H. Satz - Phys Lett. 178B(1986) 416.
- [3] J. Badier et al. - Z. Phys. C20(1983) 101.
- [4] M.J.Corden et al. - Phys. Lett. 110B(1982) 425.
- [5] M.E. Duffy et al. - Phys. Rev. Lett. 55(1985) 1816 ; H. Cobbaert et al. - Phys. Lett. 191B(1987) 456.
- [6] S. Saha and B. Sinha - Phys. Lett. B198(1987) 543.
- [7] R. Salmeron , internal note of the NA38 collaboration and private communication.
- [8] C. Pajares and A.V. Ramallo - Phys. Rev D31(1985)2800.
- [9] A. Capella, C. Pajares and A.V. Ramallo - Nucl. Phys. B241(1984)75.
A. Capella, J. A. Casado, C. Pajares, A.V. Ramallo and J. Tran Thanh Van - Phys. Rev. D35(1987)2921.
A.V. Ramallo in Proceedings of the XXII Rencontre de Moriond, ed J. Tran Thanh Van, Paris, 1987.
- [10] This value is somewhat larger than the ones measured by the EMC collaboration(see

- J.J. Aubert et al. — Nucl. Phys. B213(1983)1) and the photoproduction experiments (see for example K. J. Anderson et al. — Phys. Rev. Lett. 36(1976)237. This discrepancy is perhaps a manifestation of the strongly absorbed component.
- [11] A complementary calculation of the J/ψ suppression resulting from the J/ψ absorption as a function of the impact parameter has been performed by C. Gerschel and J. Hüfner. Their conclusions are similar to ours.
- [12] J.L. Cardy and G.A. Winbow — Phys. Lett. 52B(1974)95.; C.E.DeTar, S.D.Ellis and P.V. Landshoff — Nucl. Phys B87(1975)176.
- [13] V.A. Abramovski,V.N.Gribov and O.V.Kancheli —Yad. Fiz. 18(1983)595(Sov. J. Nucl. Phys. 18(1974)308).
- [14] R. Blankenbecler, A. Capella, J. Tran Thanh Van, C. Pajares, and A.V. Ramallo — Phys. Lett. 107B(1981)106.