Charmonium Absorption Cross Section by Nucleon

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Recent studies of J/Ψ absorption cross sections by pion and rho mesons based on meson-exchange models show that they have values of a few mb [1, 2, 3], which are comparable to that used in the comover model [4] for explaining the observed J/Ψ absorption in heavy ion collisions at SPS [5]. Since these cross sections cannot be directly measured, it is useful to find empirical information which can constrain their values. One such constraint is the J/Ψ absorption cross section by a nucleon, as this process can be viewed as J/Ψ absorption by the virtual pion and rho meson cloud of nucleon. From photo production of J/Ψ from nucleus, the cross section for J/Ψ absorption by nucleon can be extracted, and its magnitude has been found to be a few mb [6].

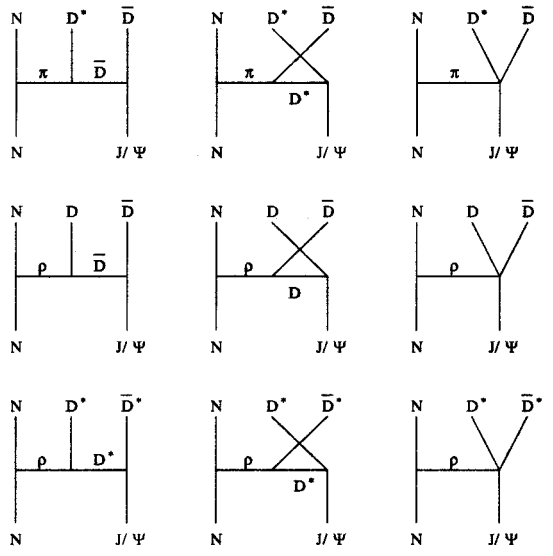

Figure 1: J/Ψ absorption by nucleon via pion and rho meson exchanges.

Possible processes for J/Ψ absorption by nucleon involving virtual pion and rho meson are $J/\Psi N \to ND^* \overline{D}$ $(N\overline{D}^* D)$, $J/\Psi N \to ND\overline{D}$, and $J/\Psi N \to ND^* \overline{D}^*$, as shown by the diagrams in Fig. 1. The cross sections for these processes can be evaluated using the same interaction Lagrangians introduced in Refs. [1, 2, 3] for J/Ψ absorption by pion and rho meson. These Lagrangians are based on the gauged SU(4) flavor symmetry but with empirical masses. The coupling constants are taken, if possible, from empirical information. The SU(4) relations are then used to relate unknown coupling constants to the known ones.

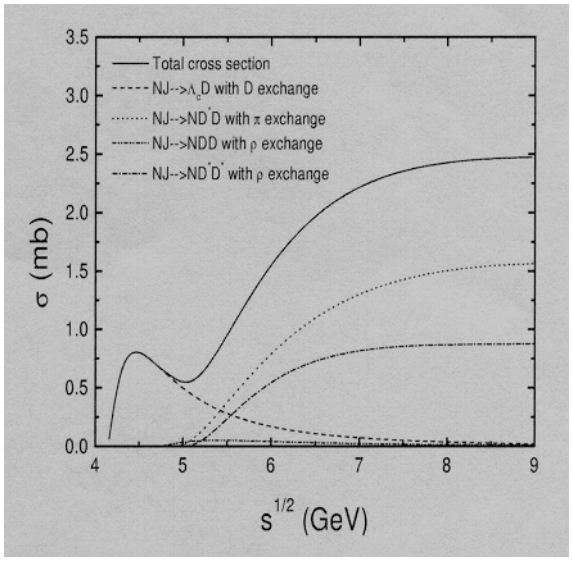

Figure 2: J/Ψ absorption cross sections by nucleon as functions of center-of-mass energy.

Including form factors with the same cutoff parameter as in Refs. [1, 2, 3], we have evaluated the cross sections for J/Ψ absorption by nucleon, and they are shown in Fig. 2 as functions of total center-of-mass energy. It is seen that all cross sections are less than 2 mb. Furthermore, the cross section for $J/\Psi N \to ND^* \overline{D}$ (dotted curve) due to pion exchange is larger than those for $J/\Psi \mathrm{N} \to ND^* \overline{D}$ (dash-

dotted curve) and $J/\Psi N \rightarrow N D \bar{D}$ (dash-dot-dotted curve) that are due to rho exchange.

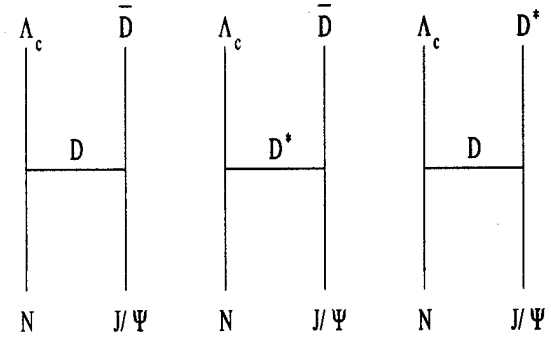

Figure 3: J/Ψ absorption cross section by nucleon via charm meson exchange.

Besides absorption by virtual pion and rho meson from the nucleon, J/Ψ can also be absorbed by nucleon via the charm meson exchange in the reaction $J/\Psi N \rightarrow \Lambda_c \bar{D}$ shown by the first diagram in Fig. 3. Following Ref. [7], we relate the coupling constant $g_{\Lambda cND}$ to $g_{\Lambda NK}$ using the SU(4) relation. The resulting cross section for $J/\Psi N \rightarrow \Lambda_c \bar{D}$ is shown in Fig. 2 by the dashed curve. Its value is less than I mb. We have also shown in Fig. 2 by the solid curve the total J/Ψ absorption cross section by a nucleon obtained by adding the contributions from all processes in Fig. 1 and the first process in Fig. 2. Its value is at most 2.5 mb and is consistent with that extracted from photo production of J/Ψ from nucleus.

There are also anomalous parity interactions of J/Ψ with charm mesons, which lead to the reactions $J/\Psi N \rightarrow \Lambda_c \bar{D}$ via D^* exchange and $\Lambda_c \bar{D} N \rightarrow \Lambda_c \bar{D}^*$ via D exchange shown by the second and third diagrams in Fig. 3. If we take the anomalous coupling constant $g_{\Psi DD^*}$ to be the same as $g_{\Psi DD}$ as in Ref [3], then the cross sections for these two reactions have values less than 1.5 mb. On the other hand, if the anomalous coupling constant is determined from the radiative decay of D^* to D using the vector dominance model as in Ref. [8], then these cross sections are increased by an order of magnitude. In this case, the total J/Ψ-nucleon absorption cross section would exceed the empirical value.

Our results thus indicate that the cross sections for J/Ψ absorption by pion and rho meson evaluated in the meson-exchange model is not in contradiction with the empirical cross section for J/Ψ absorption by a nucleon. The large anomalous coupling of J/Ψ to charm mesons as determined by the vector dominance model is, however, inconsistent with the empirical J/Ψ-nucleon absorption cross section.

References

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