In relativistic heavy ion collisions $J/\psi$ suppression has been recognized as an important tool to identify the possible phase transition to quark-gluon plasma (QGP) [1] (for a review of data and interpretations see refs. [2,3]). Since there is no direct experimental information on $J/\psi$ absorption cross sections by hadrons, several theoretical approaches have been proposed to estimate their values. In order to elaborate a theoretical description of the phenomenon, we have first to choose the relevant degrees of freedom. Some approaches were based on charm quark-antiquark dipoles interacting with the gluons of a larger (hadron target) dipole [4-6] or quark exchange between two (hadronic) bags [7,8], QCD sum rules [9-11], whereas other works used the meson exchange mechanism as in ref. [13], but we will treat the VVV and four-point couplings in the effective Lagrangians of [14]. In this work we will evaluate the $J/\psi - K$ cross section using a meson-exchange model as in ref. [13], but we will treat the VVV and four-point couplings in the effective Lagrangians as in ref. [14].

As in refs. [13-16] we start with the SU(4) Lagrangian for the pseudo-scalar and vector mesons. The effective Lagrangians relevant for the study of the $J/\psi$ absorption by kaons are:
where we have defined the charm meson and kaon isodoublets $D \equiv (D^0, D^+)$, $D^* \equiv (D^{*0}, D^{*+})$ and $K \equiv (K^0, K^+)$. 

The processes we want to study for the absorption of $J/\psi$ by kaons are:

\begin{align}
K J/\psi &\rightarrow D_s D^* \\
K J/\psi &\rightarrow D_s^* D \\
K J/\psi &\rightarrow D_s^* D^*
\end{align}

The two processes in eqs. (9) and (10) have the same cross section. Therefore, in Fig. 1 we only show the diagrams for the first process in eqs. (9) and (10).

![Diagrams for J/ψ absorption processes](image)

Figure 1. Diagrams for $J/\psi$ absorption processes: 1) $K J/\psi \rightarrow D_s D^*$; 2) $K J/\psi \rightarrow D_s^* D$. Diagrams for the processes $K J/\psi \rightarrow \bar{D}_s D^*$ and $K J/\psi \rightarrow \bar{D}_s^* D$ are similar to (1a)-(1c) and (2a)-(2c) respectively, but with each particle replaced by its anti-particle.

Defining the four-momentum of the kaon, the $J/\psi$, the vector and pseudo-scalar final-state mesons respectively by $p_1$, $p_2$, $p_3$ and $p_4$, the full amplitude for the first process $K J/\psi \rightarrow D_s D^*$, without isospin factors and before summing and averaging over external spins, is given by

\[ M_1 \equiv M_1^{\nu \lambda} \epsilon_{2\nu} \epsilon_{3\lambda} = \left( \sum_{i=a,b,c} M_{1i}^{\nu \lambda} \right) \epsilon_{2\nu} \epsilon_{3\lambda}, \]

with

\[ M_{1i}^{\nu \lambda} = -g_{KD_s D^*} g_{D_s D^*} (-2p_1 + p_3)^\lambda \left( \frac{1}{t - m_D^2} \right) \times (p_1 - p_3 + p_4)^\nu, \]

\[ M_{12}^{\nu \lambda} = g_{KD_s D^*} g_{D_s D^*} (-p_1 - p_4)^\nu \left( \frac{1}{u - m_D^2} \right) \times \left[ g_{\alpha \beta} - \frac{(p_1 - p_4)_\alpha (p_1 - p_4)_\beta}{m_D^2} \right] \left[ (-p_2 - p_3)^3 g_3^\lambda + (p_1 + p_3 - p_4)^3 g_3^\lambda \right], \]

\[ M_{1c}^{\nu \lambda} = -g_{KD_s D^*} g_3^\lambda, \]

where $t = (p_1 - p_3)^2$ and $u = (p_1 - p_4)^2$.

Similarly, the full amplitude for the second process $K J/\psi \rightarrow D_s^* D$ is given by

\[ M_2 \equiv M_2^{\nu \lambda} \epsilon_{2\nu} \epsilon_{3\lambda} = \left( \sum_{i=a,b,c} M_{2i}^{\nu \lambda} \right) \epsilon_{2\nu} \epsilon_{3\lambda}, \]

with

\[ M_{2a}^{\nu \lambda} = -g_{K D_s D^*} g_{D_s D^*} (-2p_1 + p_3)^\lambda \left( \frac{1}{t - m_D^2} \right) \times (p_1 - p_3 + p_4)^\nu, \]

\[ M_{2b}^{\nu \lambda} = g_{K D_s D^*} g_{D_s D^*} (-p_1 - p_4)^\nu \left( \frac{1}{u - m_D^2} \right) \times \left[ g_{\alpha \beta} - \frac{(p_1 - p_4)_\alpha (p_1 - p_4)_\beta}{m_D^2} \right] \left[ (-p_2 - p_3)^3 g_3^\lambda + (p_1 + p_3 - p_4)^3 g_3^\lambda \right], \]

\[ M_{2c}^{\nu \lambda} = -g_{K D_s D^*} g_3^\lambda. \]

We can see that the differences between these two processes are basically due to the meson exchanged. It can be shown [14] that the full amplitudes $M_i^{\nu \lambda}$ (for $i = 1, 2$) given above satisfy current conservation: $M_i^{\nu \lambda} p_{2i} = M_i^{\nu \lambda} p_{3i} = 0$.

After averaging (summing) over initial (final) spins and including isospin factors, the cross sections for these two processes are given by

\[ \frac{d\sigma_i}{dt} = \frac{1}{192\pi s p^{2}_{0,cm}} M_i^{\nu \lambda} M_i^{\nu' \lambda'} \left( g_{\nu \nu'} + \frac{p_{2\nu} p_{2\nu'}}{m^2} \right) \times \left( g_{\lambda \lambda'} - \frac{p_{3\lambda} p_{3\lambda'}}{m^2} \right), \]

with $s = (p_1 + p_2)^2$, and

\[ p^2_{0,cm} = \frac{s - (m_1 + m_2)^2}{4s} \left[ s - (m_1 - m_2)^2 \right], \]

is the squared three-momentum of initial-state mesons in the center-of-momentum (c.m.) frame.

To estimate the cross sections we have first to determine the coupling constants of our effective Lagrangians. Exact
SU(4) symmetry would give the following relations among the coupling constants:

\[
g_{KD, D^*} = g_{KDD^*_s} = \frac{g}{2\sqrt{2}},
\]
\[
g_{\psi DD} = g_{\psi D, D_s} = g_{\psi D^* D^*_s} = g_{\psi D^*_s D_s^*} = \frac{g}{\sqrt{6}},
\]
\[
g_{K\psi D, D^*} = g_{K\psi DD^*_s} = \frac{g^2}{4\sqrt{3}}. \tag{17}
\]

The solid line in Fig. 2 shows the total cross section of the process \( J/\psi \) dissociation by kaons evaluated by using the values for the couplings given by Eqs. (18) and (19) (dot-dashed line) and by Eq. (21) (solid line).

As can be seen by Fig. 3, the result for the cross section can vary by almost one order of magnitude, even without considering form factors in the hadronic vertices [14, 16]. This gives an idea of how important it is to have a good estimate of the value of the coupling constants. In a recent work [19], the \( J/\psi - \pi \) and \( J/\psi - \rho \) cross sections were evaluated by using form factors and coupling constants estimated using QCD sum rules [20, 21, 22, 23]. The results show that with the appropriate form factors, the total cross section can even fall for values of \( \sqrt{s} \) bigger than 4.5 GeV. In a future work we will include from factors in the hadronic vertices as well as anomalous parity interactions [16].

In summary, we have studied the cross section of \( J/\psi \) dissociation by kaons in a meson-exchange model that includes pseudo-scalar-pseudo-scalar-vector-meson couplings, three-vector-meson couplings, and four-point couplings. We find that these cross sections are even bigger than the \( J/\psi - \pi \rightarrow D^* D^* + D D^* \) dissociation cross section, and have a very strong dependence with the values of the coupling constants in the hadronic vertices. Resulting cross sections can vary between 5 mb and 30 mb for \( \sqrt{s} \sim 5 \) GeV, depending on the values of the couplings. Since these couplings are not known experimentally, it is very important to have better estimates for them.

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**References**