Charm meson scattering in hadronic matter

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Since charm quarks undergo strong radiative energy loss in a quark-gluon plasma, study of charm meson spectrum in heavy ion collisions may thus provide useful information on the properties of the quark-gluon plasma formed in these collisions. This requires, however, the understanding of charm meson interactions with hadrons as they may also affect the final charm meson spectrum.

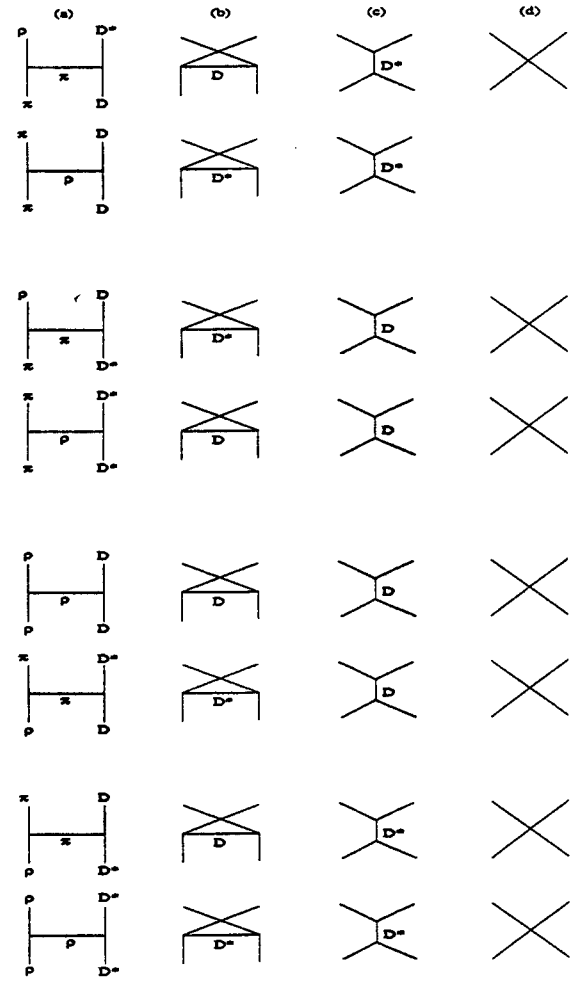

Figure 1: Diagrams for charmed meson scattering by pion and rho meson. The labels (a), (b), (c), and (d) denote the different amplitudes for the same process.

In a previous study [1], the charm meson scattering cross sections with pion and rho meson have been evaluated in a simple hadronic model that includes only the exchange of pion and rho meson in the $t-$channel (diagrams (a) in Fig. 1) and the formation of charm resonances in the $s-$channel (diagrams (c) in Fig. 1). Using reasonable form factors at the interaction vertices, the thermal average of these cross sections are found to have values of about 10 mb in the temperature range of interest. In a schematic model for the dynamics of heavy ion collisions, rescatterings of the charm mesons in the hadronic matter are found to enhance significantly the inverse slope of their transverse mass spectrum.

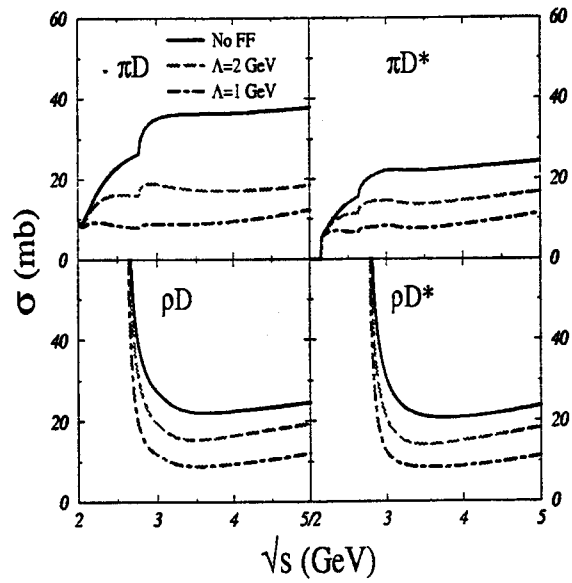

Figure 2: Charm meson scattering cross sections with pion and rho meson with ($\Lambda = 1$ and 2 GeV) and without (No FF) form factors as functions of center-of-mass energy.

The above hadronic Lagrangian has recently been extended via the SU(4) flavor gauge invariance to include also the exchange of charm mesons in the $u-$channel (diagrams (b) in Fig. 1) and diagrams involving four particle contact interactions ((d) in Fig. 1). Using coupling constants given either by the SU(4) symmetry or the vector meson dominance model, we have reevaluated the charm meson scattering cross sections by pion and rho meson. The energy dependence of these cross sections are shown in Fig. 2 with and without form factors at the interaction vertices. We see that the charm meson scattering cross sections by pions increase from threshold while those by rho mesons diverge near threshold because the latter are exothermic processes. Values for these cross sections are, however, dependent on the value of the cutoff parameter in the form factors. Although there are three or four amplitudes in each process, the ones corresponding to diagrams (a) are found to dominate near the threshold. As a result, inclusion of the flavor SU(4) gauge invariance in the hadronic Lagrangian does not significantly change the cross sections obtained previously from only diagrams (a) and (c). This is in contrary to the case of charmonium absorption by hadrons, where inclusion of the flavor gauge invariance increases the J/ψ absorption cross section by pion by an order of magnitude [2, 3] due to the absence of pion-exchange contributions.

We have also evaluated the thermal average of the charm meson scattering cross sections, and the results are shown in Fig. 3. Again, their values are similar to those in the previous study that includes only diagrams

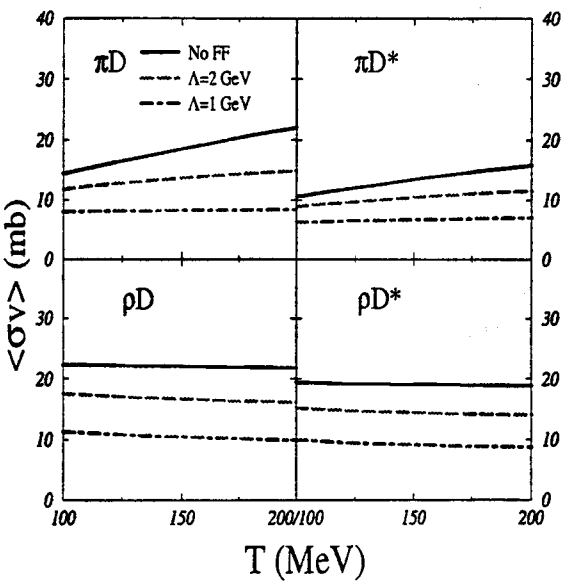

Figure 3: Thermal average of charm meson scattering cross sections with ($\Lambda = 1$ and 2 GeV) and without (No FF) form factors as a function of temperature.

(a) and (c) [1]. With such large thermal averaged cross sections, the momentum spectrum of charm mesons in relativistic heavy ion collisions is expected to be appreciably affected by the final hadronic matter.

References

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[2] K. Haglin, Phys. Rev. C 61, 031902 (2000).

[3] Z. Lin and C. M. Ko, nucl-th/9912046.