Charm Meson Production from Meson-nucleon Scattering

W. Liu and C. M. Ko

Because of their large masses, one expects charm mesons to be mostly produced in the initial preequilibrium stage of relativistic heavy ion collisions. They have thus been suggested as possible probes of the initial dynamics in these collisions. Previous studies have been concentrated on the production of charm quarks from the preequilibrium partonic matter [1]. For charm meson production from nonpartonic matter, the only study is the one [2] based on the Hadron-String Dynamics (HSD) [3] using hadronic cross sections obtained from the Quark-Gluon String Model (QGSM). The QGSM model treats charm meson production from pion-nucleon scattering as a process involving the exchange of the vector charm meson Regge trajectory in *t*-channel. Contributions from the *s* and *u* channels are neglected. To check the validity of this approximation, we have used an effective hadronic Lagrangian based on the flavor SU(4) symmetry but with empirical hadron masses [4]. The coupling constants are taken, if possible, from empirical information. Otherwise, the SU(4) relations are used to relate the unknown coupling constants to the known ones. This Lagrangian has recently been used to study the cross sections for both J/ψ absorption [5] and charm meson scattering [6] by hadrons.

Possible processes for charm meson production from meson-nucleon scattering are $\pi N \to D\overline{\Lambda}_c$ and $\rho N \to D\overline{\Lambda}_c$ as shown by the Feynman diagrams in Fig. 1. For both pion-nucleon and rho-nucleon reactions, there are *t* channel charm meson exchange diagrams, *s* channel nucleon pole diagrams, and *u* channel charm baryon pole diagrams.

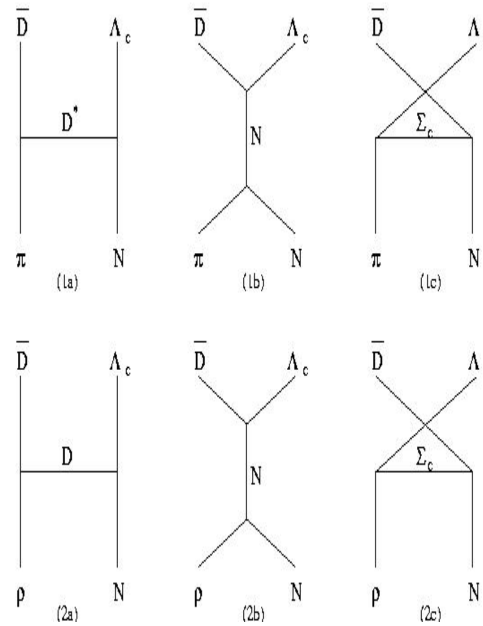

Figure 1: Charm meson production from meson-nucleon scattering.

With a cutoff parameter $\Lambda = 1\,GeV$ in the form factors introduced at the interaction vertices, we have evaluated the dependence of these cross sections on the center-of-mass energy, and they are shown in Fig. 2. For the reaction $\pi N \to D\overline{\Lambda}_c$ (dotted curve), it has a peak value of about 0.2 mb, mainly due to the *s* channel that involves a nucleon pole. The contribution from the *t* channel charm vector meson exchange at low center-of-mass energy has a similar magnitude as found in the QGSM model [2], while the *u* channel contribution is indeed negligible. The cross section for the reaction $\rho N \to D\overline{\Lambda}_c$ (solid curve) is about a factor of two larger than that from the pion-nucleon scattering. Again, the contribution from the *s* channel is the largest, while the *t* and *u* channel contributions are much smaller.

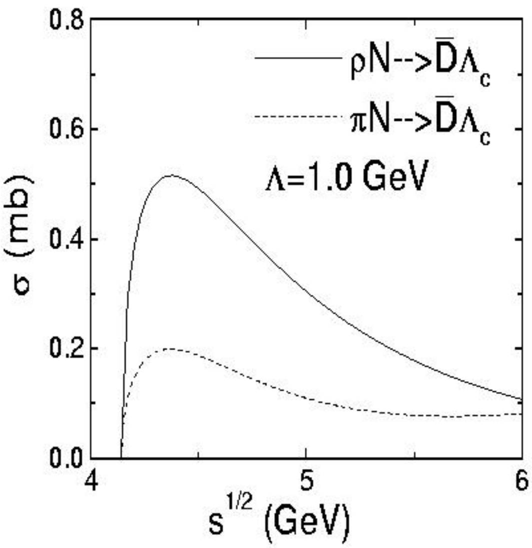

Figure 2: Cross sections for charm meson production from meson-nucleon scattering as functions of center-of-mass energy.

The magnitude of the production cross sections for charm mesons depends strongly on the value of the cutoff parameter. If we use a larger value of $\Lambda = 2\,GeV$, as suggested by the QCD sum rules [7], they are increased by an order of magnitude. On the other hand, their values are reduced by more than an order of magnitude if a smaller value of $\Lambda = 0.5\,GeV$ is used. We note that to reproduce the empirical cross section for kaon production from pion-nucleon scattering, i.e., $\pi N \to K\Lambda$, using the same SU(4) invariant Lagrangian at the Born approximation requires $\Lambda = 0.4\,GeV$. Because of smaller charm meson size, we expect, however, that the cutoff parameter at interaction vertices involving these particles should have a larger value than at those involving strange hadrons. Using $\Lambda = 1 GeV$ for charm meson production thus seems reasonable.

Since our cross sections for charm meson production are much larger than that given by the QGSM model, they would lead to too large an enhancement of charm meson production if used during the initial string stage of heavy ion collisions as in Ref. [2]. On the other hand, more reasonable results for charm production are expected if these cross sections are used only for collisions between mesons and baryons in the hadronic matter.

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