\[ \bar{D}N \text{ INTERACTION BASED ON MESON-EXCHANGE AND QUARK-GLUON DYNAMICS} \]

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Abstract

We introduce a meson exchange model, supplemented with short-distance contributions from one-gluon-exchange, to investigate the \( \bar{D}N \) interaction at low energies. The main ingredients are provided by vector meson (\( \rho \), \( \omega \)) exchange and higher-order box diagrams involving \( \bar{D}^* N \), \( \bar{D} \Delta \), and \( \bar{D}^* \Delta \) intermediate states. The short range part is assumed to receive additional contributions from genuine quark-gluon processes. It is found that the \( \omega \)-exchange plays a very important role. Its interference pattern with the \( \rho \)-exchange clearly determines the qualitative features of the interaction.

1 Introduction and Motivation

In the present communication we report selected results from our recent investigation of the \( \bar{D}N \) interaction within a meson-exchange model and a quark model utilizing one-gluon-exchange (OGE) [1]. There are several reasons for studying the interactions of \( D \) mesons with nucleons. One reason is that \( D \) mesons can provide important clues on mechanisms of chiral symmetry restoration in a hot and/or dense medium. This is so because the properties of the light quarks in a \( D \) meson are sensitive to temperature and density, and thus \( D \)-meson properties like masses and sizes are expected to change in medium, and likewise their interactions with ordinary hadrons can be expected to change in medium. However, a reasonable understanding of the interaction in free space is required before one can infer in-medium changes of the interaction. There are planned experiments by the PANDA collaboration at FAIR (GSI) to measure such interactions and estimates for the magnitude of such cross sections are urgently required.

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2 The model

Our model for the $\bar{D}N$ interaction is an extension of the $KN$ meson-exchange model of the Jülich group [2–5], generalized by assuming SU(4) symmetry. Not only single-meson (and baryon) exchanges are taken into account, but also higher-order box diagrams involving $\bar{D}^*\Delta$, $\bar{D}^*\Delta$, and $\bar{D}\Delta$ intermediate states. All meson-meson-meson and baryon-baryon-meson vertices are furnished with form factors, which are taken over from Ref. [3]. The rational for this is based on the notion that those form factors parameterize predominantly the off-mass-shell behavior of the exchanged particles, which are the same for the $\bar{D}N$ and $KN$ systems. With respect to the contributions in the scalar sector we consider them as being due to correlated $\pi\pi$ exchange, analogous to the $KN$ system [3]. But we investigate also a scenario assuming genuine scalar-meson exchange.

The short-distance quark contribution is based on a quark-interchange process [6], as for $KN$ system in Ref. [4]. We use the dominant contributions of the OGE exchange, namely the Coulomb and spin-spin parts. Since the mass of the $c$ quark is much heavier than the mass of the $s$ quark, the size parameter of the $D$ and $K$ mesons wave functions are different and, therefore, the $\bar{D}N$ interaction due to the quark-interchange process differs from the one for $KN$.

The explicit expressions for the interaction Lagrangians, SU(4) symmetry relations for the coupling constants, the quark model expressions for the effective $\bar{D}N$ interaction, and the values of parameters are given in great detail in Ref. [1].

3 Results and Conclusions

Fig. 1 presents the different meson-exchange contributions to the total cross-section, starting with $\rho$ exchange (dashed), then adding $\omega$ (dash-dotted) and so on. The most remarkable result is that for $I = 0$ there is a destructive interference between $\rho$ and $\omega$ exchanges. On the other hand, for $I = 1$ both contributions add up. Also seen is that the addition of the scalar contributions and of baryon ($\Lambda_c(2285)$, $\Sigma_c(2455)$) exchange influences the results for $\bar{D}N$ very little. The cross sections in both isospin channels are of comparable magnitude.

Fig. 2 presents results when adding the short-ranged quark contribution, and for treating the scalar contribution as being either due to correlated $\pi\pi$ or genuine scalar-meson exchange. The main conclusion is that the (repulsive) quark-gluon contribution strongly affects the threshold behavior, and their
effect is stronger in the $I = 1$ channel. Also, as seen in the figure, the different assumptions about the nature of the scalar contribution lead to very different results for the $I = 1$ channel.

![Figure 1](image1.png)

**Figure 1:** $\bar{D}N$ cross sections in the isospin channels $I=0$ (left panel) and $I=1$ (right panel) including consecutively $\rho$ (dashed curve), $\omega$ (dash-dotted), scalar mesons and baryon-exchange diagrams (dotted), and box diagrams (solid).

We have also calculated scattering lengths, finding $a^{I=0} = -0.13$ fm, $a^{I=1} = -0.29$ fm, for the quark-gluon interaction alone and $a^{I=0} = 0.07$ fm, $a^{I=1} = -0.45$ fm, for the full model. The former results are close to the values found by Lutz and Korpa [7] while the latter are qualitatively very similar to the results obtained for the $KN$ interaction [3]. They are also in good agreement with the results presented by Laura Tolos at this meeting [8].

![Figure 2](image2.png)

**Figure 2:** Full model, including meson-exchange and OGE. Solid lines are for scalar contributions due to correlated $\pi\pi$ exchange, and dashed lines are for genuine scalar-meson exchange.
In conclusion, the most interesting finding of our study is the important role played by the $\omega$-exchange contribution. Its interference pattern with the $\rho$-exchange, which is basically fixed by the assumed SU(4) symmetry, clearly determines the qualitative features of the $\bar{D}N$ interaction. Predictions for $\bar{D}N$ where only $\rho$-exchange are taken into account differ drastically and should be regarded with caution in view of our results.

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References


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