Short-range NN properties in the processes $pd \to dp$ and $pd \to (pp)n$

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Data on the unpolarized cross section of the reaction $pd \to (pp)n$, measured recently at ANKE/COSY [1] in a kinematics similar to that of backward elastic $pd \to dp$ scattering at proton–beam energies between T_p=0.6 and 1.9 GeV, are analyzed here in a phenomenological approach. We discuss the ratio $\zeta = |A_s|^2/|A_t|^2$, where A_s and A_t are the singlet and triplet production–matrix elements. This ratio, defined in our earlier analysis [2] of $pd \to (pn)p$ data in a largely model–independent way based upon the Migdal–Watson parametrization, is sensitive to the dynamics of the pd interaction. For the numerical calculations of ζ we use the earlier experimental data on the $pd \to dp$ cross section and our recent data from ref. [1]. Using the Fäldt–Wilkin extrapolation [3] to calculate the triplet cross section, we find the surprising fact that ζ with ≈ 0.02 is constant within the errors over the whole investigated T_p range [4]. A similar, small value for the singlet admixture of a few percent was found for the FSI regions of the reactions $pd \to (pn)p$ at 585 MeV [2] and $pp \to pn\pi^+$ at beam energies of 492 MeV [5] and 800 MeV [6]. The smallness of the singlet contribution in the Δ region of the $pd \to (pn)p$ reaction can be explained by dominance of the one–pion exchange mechanism (OPE) mechanism with the subprocess $pp \to (pn)_s\pi^+$ [2].

On the other hand, the singlet-to-triplet ratio can be estimated as $\zeta = R_S \times R_I \times R_X$. Here $R_S = 1/3$ is the spin statistical factor. The isospin ratio R_I is 1 for the ONE and 1/9 for both the Δ mechanism and the vector meson–nucleon exchanges. R_X is the ratio of the spatial factors of the singlet and triplet amplitudes. For the Δ amplitude $R_X \approx 1$. Straightforward calculations with the Reid-Soft-Core (RSC) NN potential for the ONE and $T_p = 1.4 - 1.9$ GeV yield ζ_{ONE}=(5-8)% which is 3 to 4 times the experimental value. For the Δ mechanism, however, one obtains $\zeta_\Delta =\approx 1/27$ in better agreement with the value resulting from the data.

Calculations [7], using the RSC NN potential and the ONE+SS+Δ model [8, 9] including single pN scattering (SS), reproduce the measured $pd \to (pp)n$ cross section for 0.6 Gev beam energy (Fig. 1). In this region the Δ mechanism dominates due to the nearby minimum of the ONE cross section. At higher energies the strong disagreement with the data is obvious. The experimental data show no indication of the dip around 0.8 GeV, and for $T_p > 1.3$ GeV they are by a factor 2 to 4 below the theoretical prediction. A very similar discrepancy is observed for $pd \to dp$ backward elastic scattering, as can be seen from the upper part of Fig. 1. Both the earlier $pd \to dp$ and the recent $pd \to (pp)n$ data show that in the until now used model the contribution by the ONE, dominating for $T_p > 1.3$ GeV, is too strong. On the other hand, a calculation using only the Δ mechanism with a cutoff momentum $\Lambda_\pi = 0.7$ GeV/c allows one to describe the $pd \to (pp)n$ data for $T_p > 0.7$ GeV. This mechanism does not involve such high-momentum components of the NN wave function as are implied in the ONE model.

A possible conclusion would be that the deuteron and the $pp(^1S_0)$ system at short NN distances are softer than modeled by the RSC NN potential. This conclusion is supported (i) by the rather successful description of the $pd \to dp$ cross section by the pure OPE-model [9, 13], and (ii) by the strong disagreement between the ONE calculations and the T_{20} data [14]. Detailed analyses of this conjecture are in progress.

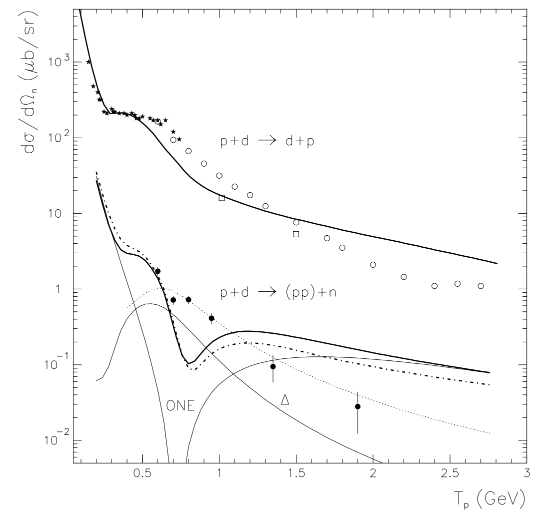

Fig. 1: Measured $pd \to dp$ [10, 11, 12] and $pd \to (pp)n$ [1] cross sections as function of beam energy in comparison with ONE+SS+Δ model calculations (thick full lines) for the RSC potential (cut-off momentum in the πNN and $\pi N\Delta$-vertices $\Lambda_\pi = 0.53$ GeV/c). The ONE(DWBA)+SS+Δ model [7], accounting for rescatterings, yields the dashed-dotted line. The dotted line results from a calculation using only the Δ mechanism with $\Lambda_\pi = 0.7$ GeV/c.

References:

[1] V.I. Komarov *et al.*, Phys. Lett. **B 553** (2003) 179.
[2] Yu.N. Uzikov *et al.*, Phys. Lett. **B 524** (2002) 303.
[3] G. Fäldt and C. Wilkin, Phys. Scripta **56** (1997) 566.
[4] Yu.N. Uzikov *et al.*, `nucl-th/0211001`.
[5] V. Abaev *et al.*, Phys. Lett. **B 521** (2001) 158.
[6] Yu.N. Uzikov, C. Wilkin, Phys. Lett. **B 511** (2001) 191.
[7] Yu.N. Uzikov, J. Phys. G: Nucl. Part. Phys. **28** (2002) B13.
[8] L.A. Kondratyuk *et al.*, Yad. Fiz. **33** (1981) 1208.
[9] Yu.N. Uzikov, Phys. Part. Nucl. **29** (1998) 583.
[10] P. Berthet *et al.*, J. Phys. G: Nucl.Phys. **8** (1982) L111.
[11] A. Boudard *et al.*, Thesis, CEA–N–2386, Saclay (1984).
[12] L. Dubal *et al.*, Phys. Rev **D 9** (1974) 597.
[13] V.M. Kolybasov, N.Ya. Smorodinskaya, Yad. Fiz. **17** (1973) 1211.
[14] L.S. Azhgirey *et al.*, Phys. Lett. **B 391** (1997) 22.

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